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PART I.—REPORT OF THE DIRECTOR

1. INTRODUCTORY

The normal activities of the Indian Agricultural Research Institute, with the integration of the Central College of Agriculture, now embrace under-graduate teaching in agriculture in addition to research and post-graduate training. Further, the development of agriculture in the light of recommendations made from time to time by the Institute in the light of new information obtained as a result of experimentation continued to remain its responsibility under the Delhi Intensive Cultivation Scheme.

Some of the results of research done at the Institute have been actually demonstrated in the cultivators' fields in villages of Delhi State. On account of their superiority over local varieties, seed of two new Pusa wheats, *viz.*, N. P. 718 and N. P. 775 particularly of the former, has been so much in demand that it has not been possible to meet it in full. Similarly, improved varieties of tomato, tobacco, peas, oats and other crops have been accepted by the cultivators as superior to their own. Improved methods of cultivation, control of diseases and pests, and use of fertilisers for raising better crops have been demonstrated in the cultivators' own holdings. Large-scale control operations against sugarcane *Pyrilla* and citrus *Psylla*, besides fumigation of a large number of rat holes, were successfully carried out. An effective and simple method of removing nematode galls from wheat seed by floatation in water proved very useful in the control of the "Tundu" disease which is assuming serious proportions in certain areas. A new system of threshing crops with the help of tractor disc was introduced in villages by which the work was completed a fortnight earlier than by the usual method of treading by bullocks. A museum of exhibits, on important aspects of farming, was set up for the benefit of the cultivators at Nangloi village. The Land Army units did useful work in the plantation of fruit trees. In order to enable the farmers to see for themselves the improved methods of agriculture, a " Farmer's Day " was organised at the Institute.

Work on wheat rusts under the Co-ordinated Wheat Rust Control Scheme has been intensified and with the co-operative efforts of the Divisions of Botany and Mycology a large-scale programme of production and testing of wheat varieties with a view to evolving resistant types has been undertaken. For this purpose a specially designed glasshouse fitted with simple cooling device has been put up at Delhi. Also additional glasshouse facilities for this work have been provided at Simla, the nerve centre of this important work, where a large number of samples of rust collections are being analysed for physiologic races on all-India basis in order to assist the wheat breeders in different regions of the country. Furthermore a much larger number of improved varieties, crosses and their progenies than at any time in the past have been tested with physiologic races of wheat rusts under spore-proof conditions. The work relating to virus diseases which has been taken up on an all-India basis under a co-ordinated scheme financed by the Indian Council of Agricultural Research also now forms a part of the responsibility of this Institute.

A large number of enquiries from the public were attended to and expert advice was given to the Union and State Governments on agricultural matters. Members of the Institute staff attended a number of scientific meetings and conferences. Besides the normal research projects of the Institute, 24 research schemes sanctioned by the Indian Council of Agricultural Research, the Indian Central Oilseed Committee, the Indian Central Sugarcane Committee and the Ministry of Food and Agriculture itself, were in operation during the year.

Dr. B. P. Pal continued as Director throughout the year except for a period of 35 days' earned leave when Dr. T. J. Mirchandani, Head of the Division of Agronomy and Principal, Central College of Agriculture, held charge of the Institute. Dr. N. Parthasarathy left the Institute on 8th September, 1952, to take over as Director, Central Rice Research Institute, Cuttack, and was succeeded by Dr. R. D. Asana as Head of the Division of Botany. Dr. B. L. Chona, Dr. P. C. Raheja, Dr. N. P. Datta and F/Lt. R. D. Verma were on deputation to the U. S. A. for 5, 6, 6 and 12 months respectively. Dr. R. S. Vasudeva, Head of the Division of Mycology and Plant Pathology, left for the U.S.A. on 19th June, 1953, under the point four (Leaders exchange) programme. Shri J. J. Chandani and Shri A. R. Khan have been officiating as Agronomists with effect from 29th April, 1953, and Shri T. J. Malkani as Plant Physiologist from 9th September, 1952. Dr. S. P. Raychaudhuri, Assistant Virologist, returned from study leave on 27th August, 1953, and Dr. M. L. Gattani reverted to the post of Assistant Plant Pathologist on expiry of his period of deputation in Rajasthan. Shri D. N. Kherdekar held the post of Mechanical Engineer (Extension) from 9th October, 1952, to 30th June, 1953. Shri B. B. Bose, Assistant Systematic Entomologist, was on leave preparatory to retirement with effect from 17th April, 1953.

Shri J. M. Banerjee held the post of Registrar till 9th December, 1952, after which he reverted to the post of Personal Assistant to the Director. Shri K. C. Gupta, officiating Personal Assistant to the Director, reverted to his substantive post of Superintendent on 10th December, 1952.

A summary of salient points of research work done in the various Divisions is given in the following pages. This is followed by detailed reports of the six Divisions. The appendices give information regarding successful students, research staff and publications of the Institute.

Accounts

The total expenditure of the Institute and its Sub-stations at Karnal and Pusa during the financial year ending 31st March, 1953, amounts to Rs. 22,72,722/- as under :—

		Rs.
I.	(1) General expenditure on the Institute including the office of the Director, Irrigation, Power Supply and Gas plant and Estate establishment.	4,96,947
	(2) Division of Statistics	22,439
	(3) Division of Chemistry	2,90,913

	Rs.
(4) Division of Mycology	1,33,755 38,126*
(5) Division of Entomology	1,95,051
(6) Division of Botany	1,95,073 69,968**
(7) Division of Agronomy	3,32,351
(8) Division of Agricultural Engineering	1,50,062
(9) Division of Economics	6,960
(10) Central College of Agriculture	1,95,752
Total	21,27,397
II. Experimental Farms—	
(a) Agricultural Research Sub-station, Karnal	86,128
(b) Botanical Sub-station, Pusa	59,197
Total	1,45,325
Grand Total of I & II	22,72,722

2. SUMMARY OF MAIN RESULTS OF RESEARCH

AGRONOMY

A. Manurial Experiments :

i. *Green manuring.*—Green manuring gave higher yields than no green manuring with Paddy, wheat and maize crops. The effect of phosphates to green manure was not noticed during the year. This is being further examined. The various 'rabi' legumes for green manuring did not show much difference amongst themselves, though berseem as green manure gave the highest yield of maize followed by Peas and Senji.

In an experiment on green manuring in conjunction with fertilizers on paddy at Karnal, it was seen that the green manuring with *'Dhaincha'* showed significant differences over no green manuring. Addition of nitrogen in the form of Ammonium sulphate at the rate of 20 and 40 lbs. to Paddy after manuring showed no response.

ii. *Nitrogenous manures and fertilizers.*—In a comparison of sulphate of ammonia, cake and F. Y. M., Cake and ammonium sulphate gave nearly the same response at the same level of nitrogen supply. F. Y. M. at 120 N was comparable with 20 lbs. N in Sulphate of ammonia or cake. No residual effect of the above was seen on maize.

The yield of barley was increased with the application of nitrogen. 20 lbs. N gave significant increase over no nitrogen and 40 lbs. N gave significant increase over 20 lbs. N. Application of 80 lbs. P_2O_5 alone gave significant increase over

* and Co-ordinated Wheat Rust Control Scheme (Mycological Portion)

** and Co-ordinated Wheat Rust Control Scheme (Botanical Portion)

lower doses of P_2O_5. The interaction between nitrogen and P_2O_5 did not show significant results.

The experiment on the manuring of paddy has shown that there was response with the application of nitrogen only. The doses of 60 lbs., 30 lbs. and control gave the yields of 25·4, 22·8, 19·6 mds. per acre respectively. The differences between different dozes and control were significant. There was no response with P_2O or K_2O.

iii. *Role of phosphate manuring of berseem.*—In an experiment berseem crop was manured with P_2O_5 in form of F. Y. M., Super and combination of F. Y. M. and Super for 3 years continuously in a rotation of berseem-Cowpeas. After 3 years' continuous growing of berseem, wheat was taken in a rotation of fallow—Wheat and Cowpeas—Wheat. The results of two years after 3 years' continuous berseem show that in case of cowpeas—wheat rotation, residual effect is seen for a year only. In case of fallow—wheat residual effect was clear in the second year also.

B. Cultural Experiments :

The experiments on the Tractor cultivation 10″ deep and bullock cultivation with inversion plough or country plough have shown that there is hardly any effect of above methods of cultivation on the yield of wheat, cotton, sugarcane, etc. This indicates that there is no difference between cultivation by country plough or by tractor so long as seed bed preparation is maintained at high level.

In another experiment, it was found that in case of wheat it is desirable to have at least 9 cultivations for seed bed preparation.

The optimum range of sowing period for cotton lies between end April and end May. The suitable varieties for the tract are F-216, F-320 and M-4. The optimum spacing between rows is 2 ft.

Jute can be successfully grown at Delhi both for fibre and seed. The sowing of Jute could be spread from end March to end May. Variety 0-40-753 is better suited to Delhi conditions as compared to D-154.

Experiments on seed rate on wheat do not indicate significant differences between 50, 65, 80, 95 and 110 lbs. per acre. Use of 2-4-D weedicide did not reveal any difference in yield.

C. Rotations, etc. :

The experiments on the effect of various rotations, mixed cropping—its mixture, suitable ratios, methods of sowings were in progress.

D. Varietal Experiments :

Varietal trials with Chillies indicated that N. P. 5-1-5 gave the highest yield of 48 mds. of dry chillies per acre. Trials with maize hybrids show that Dixie strains of maize hybrids have shown better performances.

Trials with wheat have shown that N. P. 718 has given the highest yield per acre. Varieties N. P. 718, 781, 720, 721, C 518 do not show significant differences at Karnal.

E. Agrostology : Grasses & legumes collections :

The total number in the nursery is 177 now. Some of the promising grasses and legumes are :

1. *Urochloa mosanbicucensis* and *Urochloa Sp.* 2. *Bracharia species.* 3. *Mucuna ochinchinensis.* 4. Carpet legume (*Delichos lablab*).

Ley Farming.—Experiment indicated that the introduction of *cenchrus* is likely to prove better for short ley periods and *Dichanthuium* and Rhodes for longer ley periods.

F. Cattle Breeding :

The wet and overall averages recorded during the year were 25·7 lbs., 15·5 lbs. per day per cow respectively as against 22·5 lbs. and 13·5 lbs. recorded last year. The highest wet average recorded was 29·7 lbs. in the month of April.

G. Collaborative research :

The experiments on the comparative value of Chilean nitrate with ammonium sulphate are in progress in several States in the Union since 1951 on different crops *viz.*, Wheat, Paddy, Cotton, Sugarcane and other important crops of the locality :—

The work is being conducted on Government Farms, research stations, cultivators' fields and in some community projects. The experiment was being conducted in almost 30 centres during 1952-53. The collaborative trials are also in progress on Kudzu vine and grasses and legumes in 11 and 15 centres respectively.

Intensive cultivation :

The work on the scheme has considerably increased and is showing great promise.

Seed supply :

During the year 624 mds. of various seeds were supplied.

Schemes :

Kudzu vine scheme sanctioned by I. C. A. R. was closed on its completion. The important findings were :

i. The best method of propagation of Kudzu vine is through vegetative method of propagation. Planting of Kudzu crowns during December and February has been successful.

ii. P. hirsuta from Assam shows promise due to its being winter hardy.

BOTANY

The research activities of the Division of Botany continued under the four Sections comprising it. The problems under investigation included breeding of crop plants, such as wheat, linseed, pigeon pea, safflower, maize, etc., in relation, especially, to disease resistance and other economic qualities ; improvement of plant cytological technique ; cytogenetical studies of species hybrids ; crop improvement through polyploidy ; physiological investigations on factors influencing crop yields ; crop nutrition ; resistance to drought and lodging in wheat ; the use of plant hormones in plant growth and as weedicides and the introduction, collection

and trials of crop varieties and related species. In co-operation with the different State departments of agriculture and other research institutions at home and abroad much scientific information and plant material was exchanged. A large volume of advisory work was also dealt with.

(i) Plant Breeding and Genetics

The work at Delhi, Simla, Pusa and Indore on breeding for rust resistance in wheat was further intensified and co-ordinated. Large numbers of indigenous and exotic varieties and progenies of hybrids were tested for rust resistance and agronomic characters, and in the hybrid progenies, over 1,000 promising selections were made. Some of the recently-introduced wheats, *e.g.* E. 952, E. 1913, E. 1915, E. 2140 and E. 2143, appeared to possess a very useful measure of rust resistance. Trials of varieties of the recently evolved '700-series' were conducted at 25 centres in India ; many of them have given good performances at a number of places. N. P. 770 has found favour in Himachal Pradesh and other northern hills and N. P. 710 is among the varieties that have done best in U. P., Madhya Bharat and Saurashtra. In the Punjab hills, N. P. 770 and the Australian variety, Ridley (E. 572), were distinctly superior to the Punjab wheats, Pb. C. 224 and Pb. C. 250, and at Pusa (Bihar), N. P. 799 and N. P. 798 were distinctly better than the Bihar variety, B. R. 319. In *Chapatee* making tests, N. P. 775, N. P. 781 and N. P. 758 were found to be superior to Pb. C. 591.

In linseed, a further set of early-maturing, rust resistant varieties have been evolved ; they were tested in the different states for performance. Two dual-purpose strains obtained from linseed-flax hybridisation appeared to be useful for their yield of both seed and fibre-yielding straw.

In pigeon pea (*Cajanus cajan*), the wilt resistant strains, C. 15 (Pusa) and C. 15 (W. E.), evolved at this Division, gave high yields and were highly wilt resistant.

Two strains of safflower (*Carthamus tinctorius*) from Nebraska (U.S.A.) appeared remarkable for their seed yield and oil content.

The varieties, N. P. 46A and N. P. Hyb. 5-1-5 of pungent chillies, and the non-pungent variety, R-449, gave high acre-yields of fruits at Delhi.

The new selections of *hookah* tobacco (*Nicotiana rustica*), S-19, S-22 and S-20, out-yielded the control, N. P. 18 ; S-20 gave gratifying performance in cultivators' fields in some villages around Delhi.

Performance tests in tomato confirmed previous years' findings that the indigenous variety, Desi Dickson (also called Meeruti) and the American variety, Sioux, were the best performers ; the former, however, is hardier than the latter variety and crosses have been made between them for obtaining strains combining hardiness, yielding ability and good fruit characters.

In trials of a number of American maize hybrids at about 31 centres in India, N. C. 27 and Dixie 33 were among those that gave most outstanding yields as compared to the local varieties. Inbred strains of some of these hybrids have been obtained through the courtesy of the F. A. O. and the U. S. Department of Agriculture and are being multiplied for ultimate utilisation in hybridisation work. About 600 inbred lines from indigenous maize varieties were also under study ; suitable among them were used in crosses for determining their combining ability.

Experiments were commenced on the utilisation of hybrid vigour in tomato and radish also.

(ii) Cytology and Cytogenetics

Investigations on the problem of crop inprovement through polyploidy were continued in the oleiferous *Brassicæ*, linseed and sesame. In autotetraploid *toria* (*Brassica campestris* var. *toria*), the frequency of highly fertile tetraploid plants increased remarkably as a result of three years, selection by the mass pedigree selection method. About 60 per cent of the seed sterility of these polyploids appeared to be attributable to embryological abnormalities prior to fertilisation.

A plant cytological technique, involving the use of combinations of 'pretreatment' chemicals, like alphabromonaphthalene and 8-oxyquinoline, followed by fixation in chromic-osmic acid fixatives and Feulgen staining, was developed and used for critical studies on the Karyotypes of wheat species. A technique was also developed for obtaining preparations of mitosis in pollen grains of cereals.

In *Triticum* spp., the F_2 generation of *T. vulgare* (2n=42)×T. *pyramidale* (2n=28) and some amphiploids, *e.g.*, *T. dicoccum*×*T. monococcum*, *T. monococcum* ×*T. timopheevi* and *T. timopheevi*×*T. durum*, were studied in relation to cytogenetical behaviour and usefulness in breeding work.

The chromosome number of *Abelmoschus tuberculatus* Pal *et* Singh, observed to be free from the attack of the mosaic disease and insect borer, was found to be 2n=58 thus validating its ranking as a species distinct from *A. esculentus* (2n=130), the cultivated *bhindi*.

(iii) Plant Physiology

A new line of investigations was taken up in connection with the study of drought resistance. Selections of individual plants, on the basis of ear and grain number, were made from varieties raised under intermittent drought in pot-culture. Grains from low and high-yielding plants would be sown separately next season with a view to seeing if differences in performance, under drought, persist in the next generation.

Spraying with beta-indolylacetic acid, alphanaphthyl-acetic acid, beta-indolylbutyric acid and triiodobenzoic acid on wheat variety N. P. 710 had a significant stimulative effect on the grain yield ; variety Pb. C. 228, however, responded in a similar manner to the first two substances only. Pre-emergence application of weedicides in kharif (maize crop) did not show any superiority over hand-weeding both as regards control of weeds and yield of maize.

Seed-treatment with dilute 2, 4-D solutions did not show any more beneficial effect on yield of wheat than that with water alone.

It was found that the comparative low yield of Baluchistan-16, under late sowing, was due to the much slower rate of grain filling ; evidently the assimilating system of Baluchistan 16 seems to be more sensitive to atmospheric drought.

It was confirmed that application of nitrogen after 10 weeks from sowing reduced lodging effectively.

(iv) Plant Introduction and Systematic Botany

During this year, 437 seed samples of various crop varieties and related species were received from abroad, 420 samples were collected from within the country and about 700 seed samples of a variety of plant materials were supplied for trial or other experimental purposes to the different State departments of agriculture and other research institutions at home and abroad.

The introduced sweet potato variety, F. A. 17, appeared to be very widely adaptable in this country and gave, in trials, from 25 to 100 per cent increased yields over the locals. In garden peas, the American varieties, Early Badger and Sis×7-5, proved superior to all the early varieties as regards earliness and yield. Two other American varieties, Delwiche Commando and Bonneville, especially the latter, showed great promise as mid-season varieties. The Canadian cowpea variety, Dolique du Tonkin, appeared to be the best (in respect of yield of greenpods as well as grain) early-maturing variety for growing in summer.

Among the other interesting introductions, the following may be mentioned: the salt-resistant grass species, *Paspalum vaginatum*, from Australia ; three perennial species of *Zoisia* grasses ; Kudzu-23, a quick-growing American strain of Kudzu, reported to be superior to the common Kudzu and ' Naranjilla ' (*Solanum quitoense*) a South American bush, the fruits of which yield a refreshing and delicious drink.

In the Section of Systematic Botany, taxonomic study of species of varieties of *Vicia* and *Medicago* was undertaken. The Divisional herbarium has been registered in the International ' Index of Herbaria ' published by the International Bureau of Plant Taxonomy and Nomenclature, Utrecht Netherlands (1952).

SOIL SCIENCE & AGRICULTURAL CHEMISTRY

Manures & Fertilizers :

Field experiments were conducted at Delhi and at Pusa (Bihar) to compare the manurial value of dicalcium phosphate with that of superphosphate and bonemeal at equivalent phosphate level with and without nitrogen. In its direct effect on paddy at Delhi and on wheat at Pusa dicalcium phosphate proved to be as good as super but as regards the residual effect on berseem, the latter gave better results. Both dicalcium phosphate and super were significantly better than bonemeal.

Small scale field experiments with leafy matter and loppings of wild legumes, containing substantial amount of nitrogen, showed that these can be profitably used as green manure.

Experiments on the pretreatment of seeds by soaking in nutrient solutions were continued but no beneficial effect was observed. Paddy seedlings dipped in fertilizer suspensions showed some beneficial effects.

It has been found that hydrochloric acid can be successfully substituted for sulphuric acid in the preparation of dicalcium phosphate and bone manure from bones. The bone manure thus prepared contains N—8 per cent ; P_2O_5—20 percent ; Citric acid soluble P_2O_5—11 per cent.

Soil Fertility :

In accordance with the earlier observations it has been found that (1) percolation is proportional to precipitation and (2) the loss of plant nutrients is minimised when the land is cropped instead of keeping it fallow. It has also been observed that the removal of a heavy crop of sannhemp, in spite of its being a legume, had an adverse effect on the following wheat crop.

The yield of wheat has been somewhat more when it followed either a phosphate manured sannhemp used as green manure or a phosphate treated berseem with a fallow in between.

It has been found that cowpea does not respond to the application of phosphate as markedly as berseem and the yield of wheat grain obtained in berseem rotation is about 60 per cent higher than after cereal rotation, even with application of fertilizers.

Inorganic phosphate in the form of superphosphate added to compost is not converted into organic phosphorus during fermentation.

Studies on mineral deficiency symptoms of violet colouration of the leaves probably due to the formation of anthocyanin pigment was observed in tomato plants (SIOU × EC 2898 variety), after three weeks of transplantation in pots, where the level of P_2O_5 was unbalanced as compared to that of N. This was associated with low yields of fruits.

Micronutrients :

Pot culture experiments with Sudan grass conducted with Delhi and Pusa (Bihar) soils have shown that in Delhi soil muriate of potash and lime enhanced the uptake of manganese while cobalt and copper were unaffected by different treatments. In Pusa soil, muriate of potash enhanced the uptake of cobalt and copper. Ammonium sulphate and sulphur depressed the manganese uptake whereas super enhanced its uptake.

Similar experiments with *Phalaris minor* have revealed that super and lime enhanced the uptake of cobalt in Delhi soil. Ammonium sulphate and super enhanced the uptake of copper whereas lime depressed. Lime, on the other hand, enhanced the uptake of manganese. In Pusa soil, the uptake of cobalt was almost uniform under different treatments, ammonium sulphate, super and sulphur enhanced the uptake of copper.

Soil Survey :

A detailed soil survey of nearly 5,500 acres in Delhi villages under Intensive Cultivation Scheme was completed. Soil maps and maps showing the land classes were prepared. A large number of surface, sub-surface soils and profiles from normal and alkaline tracts have been analysed. The alkaline soils show high moisture equivalent. The soils are of an open texture and clay accumulates in the B horizon. The soils come under the world group of gray and brown soils of desert and semi-desert region.

The analysis of the laterite and associated white clays of Cutch soil showed that iron accumulated under reducing conditions of a fluctuating water table. The white clays contained 60 per cent as kaolin and rest as quartz.

A new type of sulphate reducing organism was found in the Cutch soils. Preliminary work has shown that the liberation of iron in the soil is, at least, partly due to the activities of these organisms.

Soil Colloids & Clay Minerals :

Thermal dehydration curves of the clay fractions from the 1st and the 5th horizons of the red and laterite soils from Hazaribagh and Kanke were found to resemble those of pure kaolinite, the inflexion tempeartures being slightly low. The electroviscous curves were also found to be almost straight lines, characteristic of kaolin. The electrometric titration curves were, however, found to contain only one inflexion point, while two were to be expected if it were kaolin. The discrepancies between the different methods may perhaps be attributed to the large amount of Fe_2O_3 in these laterite soils.

The chemical composition of the clay fraction, isolated from different soils, showed wide variations in SiO_2/Al_2O_3 and SiO_2/Al_2O_3 plus Fe_2O_3 ratios. Buffer curves of the clay fractions and some specimens of clay minerals showed that specific clay minerals impressed their characteristic base exchange and buffer properties on hydrogen clays from soils in which they form the dominant constituents.

Saline & Alkaline Soils :

The lowering of ground water level or replenishing water at suitable places in nearby ponds and wells is recommended for the control of the development of alkaline patches at the Botanical Substation, Pusa. Temperature may also be another factor in influencing the equilibrium between Ca and Na which is closely related to the development of alkalinity in soils. A new equation found to fit best the equilibrium between K and Ca in bentonite has been proposed for studying the equilibrium between Ca and Na.

Soils & Soil Conditioners :

The treatment of Krilium, Poly-Ack and Aerotil on black soil with high clay content produced bigger sized water stable aggregates as compared to the untreated soil.

Surface soil of six typical Indian soils were analysed for their amino acids by paper chromatography. No marked difference was observed in the amino acid make up of the soils though indications of their variation in quantity are present.

Oils, Fats and Oilseeds :

Detection of adulteration of ghee.—A procedure has been developed, whereby, if 0·005 per cent of ethyl ester of tyrosine is added to hydrogenated oil as latent indicator, adulteration of ghee with as low as 5 per cent of the former can be detected. The indicator is colourless, odourless and cannot be removed from the oil by any simple procedure.

Spectrographic examination of several specimens of cow's and buffalo's ghee show that they do not possess absorption bands at 228, 260 and 310 mμ. This indicates the possibility of using fatty acids, which give absorption bands at these wave lengths as latent indicators for detection of adulteration of ghee.

Quality of Oilseeds.—It has been found that contents of oil as determined for different oilseeds is the same, when benzene or carbon-tetrachloride are used as solvent. Making use of this observation, a method has been developed for rapid determination of yield and iodine value of oils, using 0·3 to 0·5 gm. specimen of the seeds. This procedure should be of considerable interest from the point of view of plant breeder.

Pesticides :

Study of the reaction between longifolene and acetic acid or monochloroacetic acid showed that about 25 per cent of the longifolene can be converted to the acetate or monochloroacetate, for which, it is likely that a commercial outlet be forthcoming. The recovered terpene has much better keeping qualities as compared to the original longifolene.

Microbiological Studies :

Inoculation with activated strain of *Azotobacter* in the presence of different energy supplying materials increased the yield of *Marua* (Ragi).

While pea and sannhemp could make use of different phosphates like super, bonemeal, Trichy-nodule and Singhbhum phosphate in varying degrees, *Guar* could use only super.

Experiments with gram conducted at a number of different stations showed that the normal methods of seed inoculation is not very satisfactory. Inoculation of soil with soil culture or with soil from the field in which gram grew well in previous years proved better than the seed inoculation.

Cowdung Gas Plant :

A large size Fuel Gas Plant capable of dealing with 5 to 6 maunds of cowdung per day has been set up. Laboratory experiments showed that under optimum conditions, about $1\frac{1}{2}$ cu. ft. of gas can be obtained per lb. of cow-dung added. It was also found that during the course of anaerobic digestion of cowdung, an appreciable fraction of the nitrogen, ranging from 15 to 20 per cent of the total, was converted into the ammoniacal form. This valuable nitrogen fraction was readily lost when the slurry was dried in the sun.

Nutritive value of cereals and other food stuffs :

Several varieties of Indian wheat have been analysed for their major constituents, thiamine, riboflavin and nicotinic acid content. Different varieties appear to vary markedly in some of their constituents, such as, nitrogen, thiamine, and nicotinic acid content which ranged from 1·6 per cent. to 2·05 per cent, 4·6 to 6·6 μg per gram and 35·0 to 64·1 μg per gram respectively.

A few samples of wheat, gluten and mango seed kernel have been analysed for their amino acid content by paper chromatographic method. Wheat and gluten contained the same number of amino acids while mango seed kernel contained an additional amino acid which appears to be γ-amino-butyric acid.

A few varieties of wheat were also analysed for their content of methionine which has been found to vary from 0·19 per cent to 0·4 per cent in different varieties.

Preparation of starch from mango seed kernel was continued. An improved method for its preparation was found to be more economical.

The Biological value of protein in ten varieties of pulses has been determined by the growth method. Their Biological value and protein content have been found to vary from 0·24 to 1·61 and 8·4 to 11·9 per cent respectively.

Different varieties of tomato have been found to contain 23·6 to 60·5 mg. of vitamin C per 100 gram of material. The ripe fruit contained the highest amount of this vitamin.

Spectroscopy :

Cathode Layer Arc Technique.—The work on the quantitative estimation of micro-elements started earlier was continued. Analysis of the intensity distribution of light emitted in different segments of the Cathode enrichment layer revealed that under the experimental conditions the light emitted by 3 mm. segment starting 1 mm. away from the cathode towards the anode was most suitable for the quantitative estimation of most of the micro-elements studied.

The intensity distribution in the cathode enrichment layer seems to depend mostly on the quantity and the nature of the arcing material such as quartz, carbon powder, and trace element mixture which, in order of their conductivity, influences the temperature of the arc.

Absorption Spectroscopy :

Work on the quantitative estimation of nicotine in tobacco and tobacco-tomato grafts was continued. Nicotine content in 36 collections of tobacco was determined by absorption spectrographic technique and the percentage of nicotine was found to vary between 0·56 to 4·0 on dry weight basis.

Miscellaneous & Advisory :

The Division of Soil Science and Agricultural Chemistry supplied 309 tins of cultures of root nodule organism of leguminous plants for inoculation purposes to outside agencies.

Notes on " The Relative Scope of Ammonium Sulphate and Ammonium Phosphate as Fertilizers under Indian Conditions " and " Fertilizer Experiments under TCA Project under Different Soil and Climatic Conditions " were supplied to the members of the Planning Commission. Ministry of Food and Agriculture, Government of India, was supplied with information regarding " Glandine " a new edible flour extracted from " Acorns " by a European Chemist and was supplied with a report on " The Survey of the Little Rann of Cutch " drawn up in consultation with the Irrigation Advisor. A note on the " Manufacture of Fuel Gas and necessity of further research on the subject " was also sent to the Ministry of Food and Agriculture.

Several notes, *viz.*, " Suggestion regarding manuring of poppy in different soil types ", " The Relative value of nitrate and ammoniacal forms of fertilizers ", and " The availability of P_2O_5 in Bonemeal in acid, neutral and alkaline soils and possibilities of using the Japanese bone digestor in Indian villages " were sent to the Agricultural Commissioner, I. C. A. R.

Mr. Holck Colding of Royal Danish Legation was supplied with information regarding the composition of Town refuge in small and medium sized towns in India.

Work on the Monograph " Agriculture in Ancient India " was continued and Vol. I has been written up.

ENTOMOLOGY

The main activities of the Division of Entomology comprised (i) research projects, (ii) training and teaching of post-graduate and under-graduate students, (iii) extension service and (iv) advisory to correspondents from India and foreign countries.

(i) Research projects

Investigations carried out on various research problems fall under five major branches of pure and applied Entomology, *viz.*, Insect Parasitology, Systematic Entomology, Ecology, Toxicology and Insect Physiology.

Insect Parasitology

Studies on the skeleto-muscular mechanism of *Lestrodryinus pyrillae* Kieff. a nymphal parasite of *Pyrilla* spp. (pest of sugarcane in N. India) with reference to its head, thoracic legs and prothorax were completed. A highly specialised type of articulation of the head with propectus which had very probably escaped notice of earlier morphologists was observed in this parasite. Unlike in other hymenopterous parasites, the occipital processes are wide apart and oppose the posterior tentorial pits but do not take part in the articulation. The cervical apodeme which is a mesal expansion in the anterior region of the horizontal apodeme is seen articulating with the occipital condyle present on the rim of the foramen magnum, thus forming a ball and socket mode of articulation, which greatly facilitates the all-round movement of the head.

Experiments were carried out to study the host preference on the sex ratio of *Stenobracon deesae* Cam. Two females bred from its natural host, *Chilo zonellus* Swinh. were selected. One of them was allowed to breed on *Corcyra cephalonica* St. larva and the other on *Chilo*. It was observed that the parasites bred on the latter host were more vigorous and healthy than those bred on the former even upto three generations.

Pupae of *Microbracon brevicornis* Wesm. when kept in the frigidaire for 10-75 days showed on emergence a graded series of dark parasites, *i.e.* from dark grey to jet black. Experiments showed that low temperature alone was responsible for the development of dark pigment in the parasites.

Superparasitism in *Braon gelechiae* Ashm. is mainly influenced by the size of the host that the parasite encounters. The number of eggs laid by a parasite and the number of host larvae parasitized is dependent on the size of the host larvae. Superparasitism is noticed only in the case of 6th and 7th instars. Similarly, superparasitism was also studied in the case of *Trichogramma evanescens minutum* R. It was observed that parasites that emerged from highly superparasitized condition were unable to mate with the healthy ones.

Taxonomic studies on Indian Ichneumonidae were continued. Sub-family Pimplinae was taken up and keys to tribes Polysphinctini and Theroniini comprising 2 genera and 10 species and a catalogue was prepared. Similar studies on Indian

Banchinae with keys to the sub-family and a catalogue of the tribe Glyptini containing 3 genera and 5 species were also made. So far 110 Ichneumonid parasites belonging to the sub-families Pimplinae, Ophioninae, Tryphoninae, Ichneumoninae, Plectiscinae, Diplazoninae, Gelinae and Mesochorinae were indexed. Further investigations on the parasites reared from San Jose Scale collected from Kashmir revealed that out of 9 species of Chalcidoidea, *Penissopterus narayani* was found to be new. Further studies in superparasitism by *Trichogramma evanescens minutum* Riley and *Microbracon gelechiae* were continued.

Systematic Entomology

Comparative studies on the morphology of male and female genitalia of Ptinidae and Anobiidae were continued with a view to differentiating the two economically important groups. Studies on the homology of the male genital armatures of Thysanoptera to differentiate the two main sub-orders, *i.e.* Terebrantia and Tubulifera were also carried out.

Genitalia of the males of *Eumenes*, *Alaster*, *Odynerus* and *Rhygchium* (Vespoidea : Eumenidae) consisting of 20 species were studied in detail. A catalogue of Eumenidae of the Oriental region except keys to the genera was completed.

Two new forms of Reduviids from Delhi, *viz.*, *Rhinocoris lapidicola* sp. n. and *R. nysiiphagus* sp. n. predators on *Nysius inconspicuus* Linn., a pest of tobacco capsules in India were described in detail.

Insect Ecology and Toxicology

The long range problem of collecting the bioclimatic data on the population fluctuation of the spotted bollworm of cotton was continued. The parasite, *Trichogramma evanescens minutum* was reared under five temperatures and two relative humidities and data collected for constructing a Biometer for this useful insect. The completion of full life-cycle took 17-23 days, 8-16 days, 7-11 days and 7-10 days at 18°C, 25°C, 30°C and 35°C respectively. The biology and bionomics of *Hieroglyphus nigrorepletus* Bol. was studied and the average nymphal periods were observed to be 7·4, 7·5, 7·5, 8·0, 9·0, 9·5, 11·1 and 13·3 days respectively for the different instars. Precision experiments were carried out to determine the optimum shape and size of the sample and the percentage of population to be sampled for estimating the population of eight species of insect pests. The normal water content was studied in 32 insect stages belonging to 19 species and water content at the time of death due to desiccation was determined in 14 insect stages belonging to 9 species. Studies on the effect of the ecological factor, *viz.*, temperture on insects' toxicological response, *viz.*, susceptibility to insecticides confirmed the earlier findings that susceptibility increases with treatment temperature but decreases with post-treatment temperature upto a certain degree. The persistence of 19 different formulations formed from six basic chemicals, *viz.*, DDT, BHC, chlordane, aldrin, parathion and toxaphene was studied under the ecological conditions prevailing in sugarcane and cotton crops. The same insecticide in the same crop was detected for different periods depending upon the test insect used as detector. In another series of experiments, a 0·25 per cent dieldrin emulsion remained toxic upto 40 days on maize plants. The order of toxicity of the different modern insecticides was determined for five species of insect pests, *viz.*, *Oxycarenus lactus*, *Rhopalosiphum*

pseudobrassicae, *Drosicha stebingi*, *Bagrada cruciferarum* and *Pyrilla* sp. Also the comparative toxicity of six fumigants to khapra larvae was tentatively determined to be : Hydrogen cyanide>Methyl bromide>Carbon disulphide>Ethylene dichloride >chlorosol>Carbon tetrachloride. Gamma BHC was found to be better than aldrin to the 1st and 2nd instar nymphs of locust (*Schistocerca gregaria*) but to the 3rd and 4th instars, BHC appeared to be better than aldrin only on the first one or two days, but later the position got reversed. The bioasay of six chlorinated terpene products synthesised in the Chemistry Division was carried out. A preliminary experiment on the effect of DDT (10 per cent dust) and BHC (4 per cent dust) on the viability and freedom from pest of twelve different seeds gave encouraging results. The I. C. A. R. Scheme on the DDT, BHC and allied insecticides was continued.

Insect Physiology

Experimental studies on the effect of different feeding substances on *Sphaerophoria scutellaris* Fabr. showed that glucose, fructose, sucrose, and maltose and mannitol significantly increased the longevity of adults as compared to starch, yeast, water only and no food or water.

Among the factors governing the production of winged aphids (alate) *Rhopalosiphum pseudobrassicae*, moisture content within their bodies and of their host-plants was studied. It was found that interaction of humidity and temperature that leads to a reduction in the water vapour pressure of the air, directly results in the decrease in the water content of the parent aphids by evaporation ; and this induces the wing development among the offspring.

MYCOLOGY AND PLANT PATHOLOGY

Wheat

Rust.—On the basis of the study of 173 collections of *Puccinia graminis tritici*, *P. triticina* and *P. glumarum*, races 15,21,24, 34, 40 and 42 of black rust ; 10, 11, 20, 26, 63, 106, 107 and 108 of brown rust and 19, 20, A, D and E of yellow rust were observed to occur in India during the 1952-53 season. Of these, races 21 and 34 of black rust, 20 and 63 of brown rust and 19 and A of yellow rust were predominant and widely distributed throughout the country.

Rust collections from more than 150 wild grasses made from different parts of the country did not reveal any new collateral host. Rust from *Vulpia myuros* proved to be *Puccinia graminis avenae*. Further evidence of oversummering of all the three rusts of wheat was obtained from upper Simla Hills (8000—9000 ft. altitude).

More than 18,000 seedlings and 82,000 adult plants of wheat were tested against the three rusts and resistant plants selected for further study. The following wheat varieties were found to be resistant in the seedling stage :—black rust : R. R. 79 and E. 1913 ; brown rust : E. 952, E. 616, E. 389, Gabo × N. P. 165 PL. 2., Gabo× N. 4 PL. 19 and Gabo × N. 4 PL. 45 ; yellow rust : none.

Rust nurseries were established at 60 stations distributed all over the country for the study of rust dissemination. Out of the 25 localities, from where information on the dates of rust appearance was received, spore showers had taken place at 20 nurseries well in advance of the initial infection of the local wheat crop.

Loose smut.—Out of 54 wheat varieties tested for their resistance to loose smut, 32 remained free from infection by all the three isolates (L_1, L_2 and L_4) of *Ustilago tritici* and may be regarded as promising from the point of view of Loose smut resistance. The results so far obtained have given no evidence of physiologic specialization within the fungus, but these results cannot be considered conclusive as most of wheat differentials did not take infection.

Tundu disease.—Comparative studies between *Corynebacterium tritici*, the causal agent of the bacterial disease of wheat, and *C. rathayi*, which causes a similar disease on *Dactylis glomerata*, showed that the two species were identical. Histopathological studies revealed the presence of the bacterium (*C. tritici*) and the nematode in the growing points of infected wheat plants. Control of the disease by Floatation Method was successfully demonstrated to the cultivators of the villages participating in the Intensive Cultivation Scheme of Delhi State.

Black Chaff.—Pathogenicity tests with 20 exotic wheat varieties considered to be susceptible to Black Chaff disease, with the bacterium isolated last year from the diseased wheat plants showing typical symptoms of Black Chaff, gave negative results. Further work is in progress.

Barley

Rust.—Seventeen rust collections of barley obtained from different parts of the country and analysed for the determination of physiologic races yielded races 21, 34, 40 and 42 of black rust, and race 19 of yellow rust. Four barley varieties were tested against individual races of black and yellow rusts in the seedling stage and found to be susceptible. Twenty exotic and one Indian barley varieties were tested against a mixture of all the races of black and yellow rusts separately and all of them were found to be susceptible. In all these various tests, about 1,200 barley plants were tested in the seedling stage and more than 3,000 in the adult stage.

"*Molya*" *disease.*—The disease was found to be associated with a *Pythium* sp. and an unidentified nematode. Pathogenicity tests with *Pythium* sp. were made, but typical symptoms of the disease could not be reproduced. Further work is in progress.

Sugarcane

Red Rot.—Out of the 225 cane varieties tested for red rot resistance, one variety (Co. 795) reacted as resistant and 161 varieties as moderately resistant by the standard Plug Method. In a similar experiment with nodal infection, which is the chief mode of red rot infection in nature, 3 varieties reacted as resistant and 7 as moderately resistant. Eight additional varieties, which were found to be resistant in the previous years' tests, were retested against six virulent isolates of *C. falcatum*; two varieties proved susceptible and the remaining six moderately resistant.

For the study of physiologic forms of the red rot fungus, 34 isolates of *C. falcatum* obtained from red rot affected canes from Punjab, Bihar and U. P. were tested. No physiologic specificity of the isolates towards individual varieties was noticed. The light, highly sporing isolates generally proved more virulent than the dark non-sporing types. Recent isolates from eastern Punjab and Bihar were found to be more virulent than the older isolates.

Comparative tests for resistance to red rot fungus of cut canes and standing canes indicated that 13 varieties out of the 20 tested showed higher infection by the cut canes method, six showed higher infection by the standing canes method, and one gave equal infection by both the methods. An experiment to test the efficacy of application of sulphur at the time of planting for increased resistance to red rot did not show any beneficial effect.

The previous results have been confirmed again that *C. falcatum* does not survive in the red rot affected cane debris which has been composted for about a year.

The perithecial stage (*Physalospora tucumanensis*) of the red rot fungus has been successfully produced in culture.

Smut.—In the varietal resistance tests, 22 varieties reacted as resistant and 15 as moderately resistant out of the 96 varieties under test.

Linseed

Rust.—Seven collections of linseed rust, obtained from Himachal Pradesh, were analysed which yielded Indian races 1, 3 and 4 of the rust. *Linum mysorens*, growing wild in Simla Hills, has been shown to be susceptible to *Melampsora lini* under artificial conditions in the glass-house. In the varietal resistance tests 39 varieties were tested both in the seedling and in the adult stages, and another 39 only in the adult stage. Of these, 15 varieties proved resistant in the seedling stage and 23 in the adult stage.

Pigeon-Pea

Wilt.—In the varietal resistance tests, three varieties (N. P. 41, C. 15 W. E. and C-38-3-1) were found to be resistant both in the field and in pots. N. P. 41 has shown complete resistance in seven out of the 9 such tests carried out since 1945.

Bajra

Green Ear Disease.—Successful infection of *bajra* seedlings has been obtained in pots by infecting the soil with oospores of *Sclerospora graminicola* at the time of sowing, but the incidence of disease was very low. Much greater infection (31·4 per cent.) was observed when the soil was infected with oospore material last February and the pots placed in the open for weathering. Experiments are in progress to study the conditions for good germination of oospores and greater infection of the seedlings.

Antibiotics

Studies on the inhibitory action of *B. subtilis* on *Fusarium udum*, the pigeon-pea wilt organism, and certain other pathogens were continued. The antibiotic principle contained in the culture filtrate of *B. subtilis* was lost when the filtrate was passed through a bed of soil. Results of the experiments with clay and sand mixtures showed that such loss was probably due to the adsorption of the antibiotic by clay particles. The antibiotic principle could be adsorbed on kaolin and then re-eluted with ethanol. The partially purified substance, thus obtained, has been found to be thermostable and gave positive protein tests. It inhibited the growth of *F. udum* in P. D. A. and germination of *Alternaria solani* spores at as low a concentration as 1 : 10,000. At higher concentrations it inactivated *in vitro* the mosaic viruses of *Vinca rosea*, Petunia and chilli. The filtrate has also been found to act systemically in tomato plants.

Physiology of Fungal Parasitism

Experiments were undertaken to determine the factors underlying the specialization of parasitism of *Fusarium solani*, which attacks both potatoes and apples, and *F. fructigenum*, which attacks only apples. These studies have indicated that the quantity of pectinase enzyme produced by the two fungi accounts for, partly at least, the differences in their parasitism. It was also found that the endoenzyme preparation from each fungus was more active than their exoenzyme in bringing about the disintegration of potato and apple discs.

Fungicides

Replicated field experiments were conducted to determine the relative efficacy of several commercial fungicides on the emergence, stand and yield of *bajra*, maize, barley and wheat. It was generally indicated that the fungicidal seed dressing improved the emergence of maize, wheat and barley ; but it did not have any appreciable effect on their tillering, height and yield. In the case of *bajra*, however, treatment with Arasan, Ceresan and copper carbonate gave better yields than the control.

Assessment of Damage

Damage caused by rust in three varieties of linseed was assessed. With moderate and heavy rust infections in N. P. 1, the losses in yield on 100-plants basis were 38·2 and 43·8 per cent. ; and on 1,000-grain weight basis, 33·8 and 35·4 per cent. respectively. The corresponding figures for the variety N. P. 11 were 75 and 92·5, and 37·9 and 66·6 ; and for the variety N. P. 12, they were 28 and 77·6, and 20·7 and 21·6, respectively. In the case of sugarcane, the crop grown from smutted setts of Co. 312 and Co. 313 showed 21·3 and 73·3 per cent. reduction in yield, respectively ; while the corresponding figures of reduction in yield, where the setts were inoculated with *Ustilago scitaminea* at the time of planting, were 30·62 and 40·49.

Microflora of stored seed grains

The ecto-and endophytic fungal flora of stored seed grains of 3 pulses and 7 vegetables were studied as also their role in lowering seed germination and the beneficial effect of fungicidal seed dressing treatment. As regards endophytic flora, a species of *Rhizopus* and *Alternaria* were observed to be predominant. Seedling injury caused by such fungal flora could be prevented and the vigour of the seedlings improved by treating the seeds with seed-dressing fungicides like Ceresan, Arasan, Semesan, Spergon and S. R. 406.

Bacterial Diseases

Studies on the bacterial brown-rot of potatoes caused by *Pseudomonas solanacearum* were continued and further evidence was obtained with regard to the occurrence of strains of this organism in the country. *Xanthomonas* sp. isolated from pomegranate leaves was found to be different from *X. carotae* and appears to be new to science.

Virus Diseases

A mutant strain of the bottle-gourd mosaic virus (*Cucumis* virus 2C) was isolated and found to be more virulent than the type virus. The type virus and its mutant, however, did not show any marked differences in their physical properties.

The virus causing yellow-vein mosaic of *bhindi* was transmitted to *Hibiscus tetraphyllus*, *H. abelmoschus*, *H. cannabinus*, *H. ficulneus* and *H. tuberculatus* with white flies (*Bemisia tabaci*). The virus differs from the one described from Poona both in symptomatology on *H. tetraphyllus* and in its ability to be transmitted readily by white-flies to *H. cannabinus*. *Althea rosea* was found to be the chief alternative host for the virus.

Thirty-three varieties of tomato and five different species of *Lycopersicon* (*L. hirsutum*, *L. peruvianum*, *L. pississi*, *L. pimpinelli-folium* and *L. glandlosum*) were tested for their resistance to tomato leaf curl both by grafting and feeding of viruliferous white-flies. The results so far obtained indicate that the percentage of infection through insect transmission in *L. hirsutum*, *L. peruvianum* and *L. pississi* was very low.

Host range and properties of the chilli mosaic virus are being studied. The virus is sap transmissible to chilli, *Nicotiana tabacum* including var. *white burley*, *N. glutinosa*, *Solanum nigrum*, *Petunia hybrida*, *Cucumis sativus*, *C. melo* var. *utilissimus* and *Carthamus tinctorium*, while *Solanum nodiflorum* and *Chrysanthamum* sp. were found to be symptomless carriers. *Aphis gossypii* has been found to be the vector.

A mosaic virus of maize was found to be sap transmissible to maize and *jowar*, and *Aphis gossypii*, *A. maidis* and *Myzus persicae* have been found to be the vectors. Varietal resistance tests for Phyllody disease of sesamum by grafting in the glass-house were in progress.

The host-vector relationship of the virus causing yellow mosaic of pumpkin was being studied. The minimum time required by the white-flies to acquire the virus from the diseased plants was found to be 15 minutes. The virus undergoes a minimum incubation period of 9 hours in the vector. White-flies were able to transmit the virus to *Cucumis sativus* and *Cucurbita pepo*. Experiments on cross-protection tests with Dolichos Enation mosaic virus and Tobacco mosaic virus were in progress. The host-range and properties of mosaic viruses of *brinjal* and *Cucurbita moschata* were also being studied.

Work on necrosis of tomato and chilli, mosaic diseases of radish, sannhemp safflower and gooseberry, mosaic and yellows of *Vinca rosea*, leafcurl of chilli and *Saponaria* sp., " Katte " disease of cardamom, " Small leaf " disease of Cotton and malformation of mango was in progress.

Systematic Mycology

Studies on the genera *Cercospora*, *Phoma* and *Peronospora* were nearly completed. Critical studies on Miscellaneous Indian Fungi were continued as a result of which seven new species and several new host records in India were reported.

AGRICULTURAL ENGINEERING

1. Tractor Tests

(*a*) *David Brown Tractor.*—A David Brown 4-cylinder diesel tractor equipped with hydraulic lift was tested. The tractor was found suitable for light soils for ploughing upto a depth of 6″—8″. For ploughing harder soils, the tubes of the

wheels should be filled with water and weight added to it. It was found that by this process the wheel slippage can be much reduced.

(*b*) *Deutz Tractor.*—Two models of air-cooled diesel engine Deutz tractors—one 2-cylinder 30 H.P. and the other single cylinder 15 H.P. were tested in the field as well as in the workshop. Both the tractors were found satisfactory and suitable for our climatic conditions. The metric system of the units of measurement and the locations and heights of trailer hooks, belt pulley, fixed draw bar etc. however, desired to be changed to conform to the standards now prevailing in India. The position of the outlet of the silencer should also be changed.

2. Trial of Disc Harrows

An Allis-chalmer Disc Harrow (24 Discs) and an Evona Giant Disc Harrow were tried in the field. The former disc harrow was hitched behind an Allis-chalmer ' B ' tractor and was found satisfactory on light sandy loam soils. The latter harrow was drawn by a Caterpiller D4 tractor. Both ploughing and discing can be simultaneously done with it. It cuts to a depth of 7″—8″.

3. Trial of Different Ploughs

(*a*) *Tractor Ploughs.*—Four tractor ploughs such as (i) Massey Harris, 3 furrow, (ii) Elite, 3 furrow, (iii) T. N. T., 2 furrow and (iv) Ferguson, 3 furrow—were tested for seed bed preparation in sandy loam soils with low moisture contents. The Massey Harris plough was found to be most suitable for soil conditions in Delhi, so far as the soil inversion and pulverisation of soil was concerned.

(*b*) *Mould Board Ploughs.*—Two types of bullock drawn mould board ploughs were tested. One type was known as ' CARE ' plough and other as ' JAI HIND ' plough supplied by M/S Cossul and Co., Kanpur and M/S Unique Metal Works, Aligarh, respectively. Both the ploughs were found satisfactory. The former plough is a little heavier than the Allahabad and similar ploughs in use in the North.

(*c*) *Country Ploughs.*—Seven types of country ploughs were tried at the Botanical Sub-Station at Pusa (Bihar) on soils containing 8·02 to 12·26 per cent. of moisture. The Bellary plough was found to be the best as it ploughed to a depth of 7″ making $8\frac{1}{2}$″ wide furrow with draft of 293 lbs. The Warrangle and Patna ploughs were considered to be the second and the third respectively in performance.

(*d*) *Double plough.*—The mild steel frame work of the double plough has been replaced by a wooden one to make it lighter in weight. The plough is now more convenient to carry as the weight has come down to 60 lbs. from 85 lbs. It was tried on hard soil with the modified frame and was found to withstand the loading. The draft was recorded to be 260 lbs. at a depth of 4″.

4. Seed Drills

(*a*) *Maize Seed Drill.*—A single row seeding attachment to a country plough for sowing maize has been developed and found successful on trial. The seed rate while sown in 2 ft. apart was 20 lbs. per acre and 3 acres of land could be sown in a day of 8 hrs.

(*b*) *Jute Seed Drill.*—A four row bullock drawn jute seed drill has been designed and manufactured in the Division and has been found successful in laboratory trials.

2 to 5 seeds are dropped every 4" and an acre of land can be sown in an hour. Seed rate is 6·20 lbs. per acre, but this can be adjusted.

5. Threshers

(*a*) *Experiment on paddy threshing.*—Threshing with various types of thresher has been conducted at the A.S.S. Karnal. The machines tried were (i) Danish Thresher (ii) Otaka Thresher (Japanese) and (iii) Akshat Thresher. The economics of threshing by various methods have been worked out for comparison with conventional method of beating the grains by manual labour.

(*b*) *Threshing wheat by a tractor and a disc harrow.*—Experiments in threshing wheat by a tractor and a disc harrow instead of bullocks, were conducted. It was found that 50—80 maunds of grains can be threshed in 10 hours with a 15 DBHP tractor and a suitable disc harrow, at a cost of Rs. 30—40 including depreciation, interest, fuel, lubricant and labour charges. This method also produces finer quality of bhusa and grains are not damaged in any way.

6. Hand operated Rotary Screen

Some modifications have been made in the hand operated screen to facilitate its quick transport. The wooden frame has been replaced by a steel one with arrangements for detachment of the rotating screen at a short notice. The advantages of (*a*) ease in working (*b*) less frequent repairs and (*c*) quicker transfer from place to place by 2 workmen, have been obtained by this modification.

3. GENERAL FEATURES OF THE REPORT

(i) Land and Buildings

The glass-house under the Delhi Centre of the Co-ordinated Wheat Rust Control Scheme was completed and an Insectory was under construction in the Mycology Division. Construction of a lecture theatre in the Botany Division was nearly completed during the year, and work was started on two new "C" type quarters.

The building in which the Rust Research Laboratory is housed at Simla was acquired by the Government and the construction of an additional glasshouse was undertaken. Construction of a research laboratory for the Wheat Breeding Substation was also completed at Simla.

(ii) Post Graduate Training

Out of 185 applicants, 50 students were selected this year for post-graduate training in different subjects. Two students were admitted to the one-year Plant Protection Course, and twelve students received short course training. Thirteen honorary research workers were given facilities of work and guidance in different Divisions. Sixty-five students successfully completed their studies in the two-year post-graduate course and were awarded the Associateship of this Institute.

(iii) Library

The library of this Institute which receives every important journal dealing with agriculture and the sciences basic to it, is considered to be the biggest agricultural library in India and one of the best in all Asia. The total number of publications received in the library both by way of exchange and purchase was 3,612

Twenty-five new periodicals were added during the year. Five thousand and thirty-eight books were issued out on loan, of which 901 were sent to the scientific workers in the States and Universities. The reading room of the library which is kept open during the day and also in the evenings was visited by 9,967 persons who were issued 81,181 books for consultation.

The library also had to deal with a large number of enquiries and supplied references and bibliographies on many and varied items. Some of these are mentioned below :—

(1) List of Agricultural Institutes and Colleges

(2) List of books on gardening

(3) Bibliography on grapes

(4) List of literature on compost

(5) Information on (i) agencies for initiation and carrying out of research work. (ii) list of Central Research Institutes and (iii) list of members of the Commodity Committee.

(6) Bibliography on fruits

(7) List of books on genetics

(8) Literature on aquatic plants

(9) List of references on (i) storage of food grains, (ii) ink manufacture, (iii) seeds, their storage and germination and (iv) Breeds of cattle in India.

(10) List of periodicals on agriculture

(11) Literature on linseed oil

(12) Information on rice cultivation in Japan

(13) Literature on grasses.

(iv) Advisory Work

Every year the Institute attends to a variety of enquiries from different institutions and from members of public. Expert advice is given whenever required. Some of the enquiries dealt with during the year are mentioned below :—

Information on all aspects of Agricultural Engineering particularly on the selection of suitable machine or implements was supplied to the public. Advice was given to the Government of India, Ministry of Food and Agriculture on various technical problems relating to Agricultural Engineering and on its policy of import control of the agricultural machines and implements as well as spare parts. At the instance of the Ministry notes were submitted on (*a*) a development programme for the manufacture of agricultural implements on cottage industry basis, (*b*) standardisation of agricultural implements, and (*c*) compilation of data on tractor performance in different States.

Plants, fruits and seeds received from the public were identified and advice was given on the cultivation of specific crops. Analyses of 442 samples of soils, manure, irrigation water and oilcakes were carried out for various State Governments and institutions.

The Director visited Bihar in August, 1952, for reviewing the sugarcane work in that State on the invitation of State Department of Agriculture. Accompanied by the Head of the Division of Botany he visited the Central Rice Research Institute, Cuttack, to deliver lectures in connection with the International Course on rice breeding conducted there under the auspices of the F.A.O.

Some officers of the Institute gave lectures at the Janata College, Alipur, Delhi, at the instance of the Board of Secondary Education, Delhi.

A note on the progress of Agronomy, and Agricultural Chemistry and Soil Sciences in India during the past 40 years was supplied to Sir Robert Allen, Edinburgh, and a scheme on Hydroponics was prepared and sent to Shri K. D. Malaviya, Dy. Minister for Education through the Ministry of Food and Agriculture.

The identification of 250 species of insect pests and their natural enemies was carried out and information relating to various insects of economic importance, their distribution, food-plants, control measures, etc., was supplied to different scientific workers in India and abroad.

One hundred and fifty cultures of fungi from the Indian Type Culture Collection and 112 mycological specimens from the Herbarium Crypt. Ind. Orient. were supplied to scientific workers in India and abroad. A number of mycological specimens received from different sources were identified.

(v) Research Schemes

In addition to the normal research projects of the different Divisions, a number of research schemes financed by the Indian Council of Agricultural Research (I.C.A.R.), the Indian Central Oilseeds Committee (I.C.O.C.), and the Indian Central Sugarcane Committee (I.C.S.C.), were in progress in the various Divisions of the Institute. They were as follows :—

Serial No.	Title of the Scheme.	Sponsored by.	Divisions in which the work was in progress.
1	Scheme for research on the cultivation of Kudzu vine .	I. C. A. R.	Agronomy and Botany.
2	Scheme for the collection of exotic and indigenous pasture grasses and legumes, their testing and distribution, and their breeding for better agronomic characters.	Do.	Do.
3	Scheme for the imrovement of maize crop in India . . .	Do.	Botany.
4	Scheme for the establishment of a nucleus organisation for the introduction of new economic plants.	Do.	Do.
5	Scheme for research on minor and trace elements . .	Do.	Chemistry.
6	Scheme for research on nitrogen fixation in soils . . .	Do.	Do.
7	Phosphate Monograph Scheme (up to 2-8-1953) . .	Do.	Do.
8	Scheme for the preparation of a monograph on agriculture in ancient India.	Do.	Do.

Serial No.	Title of the Scheme.	Sponsored by.	Divisions in which the work was in progress.
9	Scheme for setting up an experimental gas plant (from 10-1-1953).	I.C.A.R.	Chemistry.
10	Scheme for research on examination of rapid methods of soil test for soil survey work.	Do.	Do.
11	Bone meal scheme	Do.	Do.
12	Scheme for tests with D.D.T., 666 and allied insecticides	Do.	Entomology.
13	Termite research scheme (from 11-5-53) . . .	Do.	Do.
14	Scheme on school of research in Entomology . . .	Do.	Do.
15	Scheme on school of research in Mycology . . .	Do.	Mycology.
16	Co-ordinated plant virus scheme (from 31-5-1953) . .	Do.	Do.
17	Key Village Scheme	M/F&A(A)	Agronomy.
18	Co-ordinated wheat rust control scheme . . .	Do.	Botany and Mycology.
19	Scheme on the diseases of sugarcane	I.C.S.C.	Mycology.
20	Linseed rust scheme	I.C.O.C.	Do.
21	Scheme for research on phyllody diseases of sesamum .	Do.	Do.
22	Scheme for the development of a method to determine the unsaturation of a small quantity of oil.	Do.	Chemistry.
23	Scheme for agronomical studies on oilseeds . .	Do.	Agronomy.
24	Scheme for cytological studies on some oilseed crops .	Do.	Botany.

(vi) Collections and Herbaria

In addition to the different varieties of crop plants, a large collection of their wild relatives is being maintained at this Institute and forms valuable material for breeding purposes and plant introduction.

The Division of Botany maintains a small herbarium of economic plants, weeds of cultivated fields and large living collections of varieties of crop plants. The latter includes an All India collection of wheats which is being maintained and described in collaboration with the F.A.O. World Catalogue Scheme. There is also a separate collection of seeds, and a collection of living plants. About 1100 plant specimens were added to the herbarium during the year, bringing the total number of specimens to about 5,000. The herbarium has been registered in the International Index of Herbaria (1952) published by the International Bureau of Plant Taxonomy and Nomenclature, Utrecht, Netherlands.

During the year 4 species of *Reduviidae* and one of *Serphoidea* described as new to science were added to the National Pusa Collection of named insects maintained at the Entomology Division. Also 28 species of Australian insects (*Lepidoptera*)

including some of economic importance were deposited in the collection. A catalogue of *Eumenidae* (*Hymenoptera* : *Vespoidea*) of the oriental region was completed, while the catalogue of *Anobiidae* (Diptera) was in progress.

The Indian Type Culture Collection of Fungi maintained in the Division of Mycology and Plant Pathology continued to be a member of the International Federation of Culture Collection linked with UNESCO. Fifty-eight cultures were added to this collection, thus bringing the total number of cultures to 920. Three hundred and eleven specimens of fungi, including several new species or new host records for India were added to the Herb. Crypt. Ind. Orient. bringing the total number of accessions to 20,326. Two *exsiccati* sets from the U.S.A. were among the new additions.

A collection of fodder grasses and legumes is maintained in the Agronomy Division. During the year four grasses and five legumes from Assam were added to the nursery, making a total of 177.

(vii) Intensive Cultivation Work in Delhi Villages

The work on the Intensive Cultivation Scheme in 19 villages of the Delhi State was continued. The programme of work was coordinated by a committee consisting of the Director, Indian Agricultural Research Institute, New Delhi, (Chairman), the Deputy Commissioner, Delhi, the Development Secretary to the Chief Commissioner, the Development Officer and Shri Krishnan Nair, Member of Parliament. The Committee met once at Nangloi, the headquarters of the Scheme, to review the work.

A detailed survey and mapping of soils of villages Bapraula, Bakarwala and Mundka covering an area of 5,000 acres was completed and the present production potential of the soil types was computed. A large number of samples of well water had been collected and analysed. In a majority of cases excessive saline salts were found. In Qamruddin Nagar, a programme of ' bunding ' was taken up in order to conserve water and avoid soil losses.

In all 280 demonstrations were arranged on the fields of cultivators. The use of Chilean nitrate as a fertilizer for chillies, sugarcane and wheat was demonstrated on 45 plots. N.P. 718 has proved to be by far the best variety of wheat followed by N.P. 775. These varieties had been very much in demand and cover about 900 *bighas*. Barley N.P. 13, Oats N. P. 1 and N.P. 58, Sweet potato FA 17, tobacco S-20 are also becoming very popular.

Sowing of wheat in four rows simultaneously with a single pair of bullocks was demonstrated at Nangloi with a seed drill made in the Institute workshop. A new system of threshing crops with the help of tractor disc was introduced in the villages and has found great favour with the villagers on account of its time-saving merits.

Control operations against insect pests and rodents were carried out in different villages. In Qamruddin Nagar, control measures were taken against the Pyrilla pest which was serious on sugarcane. Spraying was done on citrus and guava trees against other insect pests.

Solar heat treatment of wheat N.P. 775 was given in village Nilhauti for the control of loose smut. Wheat seed was also cleaned of nematode galls by " flotation " for the control of *tundu* disease. The incidence of *tundu* disease was less than 1 per cent where gall-free seed had been used as compared to 25-75 per cent infection in other fields.

(viii) Meetings and Conferences

As in previous years, the Director, the Heads of Divisions and other officers of the Institute attended the meetings and conferences held under the auspices of the various Ministries of the Government of India, the Indian Council of Agricultural Research and the various Commodity Committees.

The Director attended, amongst others, the first meeting of the Standing Committee of the Indian Council of Agricultural Education, the Advisory Board and the Governing Body meetings of the Indian Council of Agricultural Research and served on the *ad hoc* Committee appointed to review and scrutinise the Indian Council of Agricultural Research schemes.

(ix) Supply of Pedigree Seeds and Sale of Cattle

As in previous years, the demand for pedigree seeds produced in this Institute had been so heavy that it was not possible to meet it in full in many cases. The quantities of seed of the major crops supplied are given below :—

1. Wheat	383 Maunds.
2. Barley	37½ Maunds.
3. Oats	11 Maunds.
4. Paddy	39 Maunds.
5. Gram	9 Maunds.
6. Peas	10⅛ Maunds.
7. Maize	8½ Maunds.
8. Pigeon pea	5$\frac{1}{10}$ Maunds.

The maximum demand has been for the seeds of the Pusa wheats.

During this year six young bulls and two cows were sold for a total sum of Rs. 665 only.

(x) Visitors

Besides several Members of the Parliament and high officials of the different Union and State Ministries, a large number of distinguished Indians and foreigners visited the Institute of whom mention may be made of the following :—

Members of the Japanese Parliamentary Goodwill Mission, members of the Russian Delegation, members of the Yugoslav Goodwill Mission, Members of the Press Delegation, Iran, delegates and observers from the Commonwealth countries to the Second Conference of Defence Science, Ministers for Local Government and Agriculture, Nigeria, Lord and Lady Halifax, Messrs. C. E. Wilcox, C. N. and E. N. Sanders, D. E. Lebu and H. C. Ladenheim of the T. C. A., Mrs. Raymond Seyro of UNESCO. Dr. J. B. Harrington of F.A.O., Mr. Ronald Jones of the Ford Foundation, Mr. M. L. Wilson, Director of Extension, U. S. A., Sir Herbert Broadway, Director-General, F.A.O., Dr. G. Watts Padwick, Plant Protection Adviser, F.A.O.

PART II.—REPORTS OF THE HEADS OF DIVISIONS FOR 1952-53

REPORT OF THE DIVISION OF AGRONOMY (INCLUDING AGRICULTURAL RESEARCH SUB-STATION, KARNAL) FOR THE YEAR 1952-53

(Dr. T. J. Mirchandani)

Research

During the year under report the research activities of the Division at Delhi were as under :—

Manurial Experiments

It included studies on the dozes, time of application of F.Y.M., cake and nitrogenous fertilizers to various crops ; green manuring, its time of burying, choice of crops, effect of fertilizers and their economics ; effect of nitrogen, P_2O_5 and K_2O alone or in combination on different crops ; role of phosphatic manuring of legumes in building up of soil fertility ; experiments on building up of soil fertility and micronutrients.

Cultural Experiments

It includes studies on the effect of the variation in depth with major crops ; tillage practices for major crops; placement of fertilizers ; weedicides ; sowing dates for major crops and seed rates.

Rotational Experiments

It includes studies on different rotations ; mixed cropping, etc.

Varietal experiments

Trials with improved varieties of different crops and their response to manures, etc.

Irrigation experiments

The work on the irrigation requirement of some crops has been started very recently.

Agrostology

Studies on grasses and legumes ; ley farming ; Pasture management, and maintenance of grass and legume nursery.

Cattle breeding and management

Nucleus herd of Sahiwal breed is maintained for research and training.

Collaborative research

Experiments on the comparative value of Sodium nitrate (Chilean nitrate) and ammonium sulphate are in progress in several States since 1951 on different crops. Trials of promising grasses and legumes are also in progress in various States.

A large number of experiments are in progress in different sections enumerated above but for shortage of space, results of only some of the important ones are given below.

Manurial experiments

(i) *Relative value of 'rabi' legumes for the purpose of green manuring.*—The experiment on the choice of crops for green manuring purposes has been in progress since last 3 years. Some commonly growing 'rabi' legumes were selected for trial. The legumes were sown in October-November and buried in the month of February and March each year. Maize crop was sown in June-July.

The results have indicated that various legumes, viz., Berseem, Peas, Khesari, gram, lentil, Senji and Methra helped to increase the yield of maize, but these did not differ amongst themselves significantly. Berseem gave the best performance followed by Peas & Senji.

(ii) *Response curve of nitrogen with wheat.*—The object of this experiment was to find out the standard response curve of nitrogen. The plots received a basal dressing of 40 lbs. P_2O_5 and 60 lbs. K_2O per acre. Increasing dozes of nitrogen at intervals of 10 lb. per acre upto 100 lbs. per acre were applied as top dressing and response observed. No manure plot gave an yield of 32·10 md. per acre, while the highest yield with 80 lbs. Nitrogen per acre was 39·70 mds. per acre. The treatment differences were significant, but the responses with the increasing dozes were not regular. Experiment is being continued.

(iii) *Comparison of response of Sulphate of Ammonia Oil Cake & F.Y.M. at different levels of Nitrogen on wheat.*—The object of this experiment was to find out the relative value of nitrogen in the form of F.Y.M., cake and ammonium sulphate. The manures and fertilizers are applied to wheat and the effect seen on wheat yields. After wheat, maize crop is grown to study the residual effect of manures and fertilizer applied to previous crop. The summary of results of the current year and average of last 3 years is given below :

Treatments.	Yield of wheat in mds. per acre grain.		
	1952-53.	Average of 3 years 1950-1953.	Residual effect on Maize 1952 Kharif. Yield of fodder in mds. per acre.
A. No manure	17·82	21·70	277·74
B. F.Y.M. at 40 lbs. N per acre	17·18	20·01	282·43
C. F.Y.M. at 60 lbs. N per acre	19·21	22·72	283·18
D. F.Y.M. at 80 lbs. N. per acre	19·10	23·00	260·42
E. F.Y.M. at 100 lbs. N. per acre	18·03	23·15	260·98
F. F.Y.M. at 120 lbs. N. per acre	19·10	22·64	305·17
G. Groundnut cake at 20 lbs. N per acre	19·74	22·41	291·83
H. Groundnut cake at 40 lbs. N per acre	21·77	24·89	277·21
I. Groundnut cake at 60 lbs. N per acre	22·62	25·94	288·31
J. Groundnut cake at 80 lbs. N per acre	24·33	27·86	316·91
K. Am. Sulphate at 20 lbs. N per acre	20·92	23·47	280·72
L. Am. Sulphate at 40 lbs. N per acre	21·66	24·60	293·53
'F' Test	Sig.	Sig.	Not Sig.
S. Em.	±1·23	±0·70	±23·175
C.D. at 5 per cent	3·45	1·97	

These results indicate that as nitrogen suppliers, ground-nut cake and ammonium sulphate are nearly equal while Farm yard manure even at 120 lbs. N has given less yield than 40 lbs. N as cake or Ammonium Sulphate.

Maize grown for fodder to study the residual effect of manures and fertilizers applied to previous wheat, did not show any residual significant effect, during the last two years.

(iv) *Effect of low dozes of phosphates on berseem and in building up of soil fertility.*— Berseem crop was grown for 3 years continuously every 'rabi' season with Cowpeas every 'Kharif' season. Treatments as given below were applied every year to berseem. After growing of berseem for 3 years, wheat was grown in rotation of cowpeas-wheat and fallow-wheat. The results of wheat obtained in first and 2nd year after the growing of berseem for 3 years are given below :

Treatments to berseem Crops.	Yield of wheat in mds. per acre.			
	After Cowpeas.		After fallow.	
	1951-52	1952-53	1951-52	1952-53
A. F.Y.M. 16 lbs. P_2O_5/ac.	12·79	15·35	14·92	19·13
B. F.Y.M. 32 lbs. P_2O_5/ac.	16·10	16·46	15·80	20·91
C. F.Y.M. 64 lbs. P_2O_5/ac.	18·23	15·80	18·82	20·58
D. Super phosphate at 16 lbs.	14·19	15·46	13·82	20·13
E. Super phosphate at 32 lbs.	16·91	16·46	16·91	23·14
F. Super phosphate at 64 lbs.	20·44	20·02	21·32	32·15
G. Super at 8 lbs. P_2O_5+ F.Y.M. at 8 lbs. P_2O_5	15·88	16·13	16·17	19·91
H. Super at 8 lbs. P_2O_5+ F.Y.M. at 24 lbs. P_2O_5	14·92	14·79	17·57	20·69
I. Super at 8 lbs. P_2O_5+ F.Y.M. at 56 lbs. P_2O_5	18·23	18·13	18·67	24·36
J. Super at 24 lbs. P_2O_5+ F.Y.M. at 8 lbs. P_2O_5	16·98	20·36	18·38	25·92
K. Super at 56 lbs. P_2O_5+ F.Y.M. at 8 lbs. P_2O_5	20·14	17·69	21·83	25·14
L. No manure	12·72	17·58	11·47	15·24
M. Fallow (No berseem)	9·04	11·35	11·54	12·57
'F' test	Sig.	Sig.	Sig.	Sig.
C.D. at 5 per cent	3·33	4·72	3·33	4·72

It will be seen that the residual effect of the phosphate manuring of berseem in case of cowpeas-wheat rotation, has lasted only for one year. In case of fallow-wheat, residual effect is clear in the second year also.

(v) *Manuring of Barley.*—The experiment was started last year. The results of second year of the experiment are given below :

Treatments.	Yield of Barley in mds. per acre.	Treatment.	Yield of Barley in mds. per acre.
No—No nitrogen	20·60	P_0- No P_2O_5	23·60
N_1—20 lbs. as Am./Sul. per acre	25·30	P_1-30 lbs. P_2O_5 as super per ac.	25·16
N_2—40 lbs. as Am./Sul. per acre	29·66	P_2—60—do.—	26·81
S. Em.	±0·75	S. Em.	±0·75
C.D. at 5 per cent	2·14	C.D. at 5 per cent.	±2·14
Variety	V1 N.P.-13	V_2 Kanpur 251	S. Em.
Yield in mds. per acre	25·77	24·60	±0·62

The effect of nitrogen is very evident. N_2 is better than N_1 and N_1 is better than No. 80 lbs. P_2O_5, i.e., P_2 has shown significant difference over the control. There is no significant difference between the varieties.

Cultural experiments

(i) *Cultural-cum-manurial experiment in a rotation of Maize-berseem-fallow-wheat on clay loam soil.*—Summary of results is given below :

Treatment.	Yield of grain in mds. per acre.	
	Maize.	Wheat.
Main plot.		
C_1—Tractor cultivation 10″ deep with inversion	14·00	25·21
C_2—Bullock cultivation 5·0″ deep with inversion	12·82	28·48
C_3—Bullock cultivation 4-5″ deep without inversion (country plough)	12·91	30·01
C_4—Discing by tractor	8·96	25·66
'F' Test	Sig.	Not Sig.
S. Em.	+ 1·13	±1·47
C.D. at 5 per cent	3·63 mds. per acre.	
Sub plot treatment—		
N_0—No F.Y.M.	8·57	24·30
N_1—40 lbs. N as F.Y.M.	12·06	26·11
N_2—80 lbs. N as F.Y.M.	12·36	27·93
N_3—120 lbs. N as F.Y.M.	15·70	31·02
'F' Test	Sig.	Sig.
S. Em.	+1·04	±1·02
C.D. at 5 per cent.	2·99	..

Normal depth as obtained through country plough is the optimum depth for cultivation under the conditions of the experiment. These results are in agreement with the findings of previous years. Application of 120 lbs. Nitrogen in the form of F.Y.M. appears to be optimum.

(ii) *Cultural-cum-varietal-cum-manurial experiment on sugarcane.*—The experiment is in progress for the last 3 years. Summary of results is given below :

Treatments given to plant cane only.	Average yield of S. Cane (Stripped) in mds. per acre. 1950-51 Plantcane.	1951-52 Ratoon.	1951-52 Plantcane.	1952-53 Ratoon.	1952-53 Plantcane.
(C) *Depth of cultivation.* (M. Plot).					
C_0—Desi plough 4-5″ depth	750·68	381·62	472·3	319·13	483·25
C_1—Tractor plough 6·0″ depth disc and grubbing.	737·50	376·16	515·4	302·73	511·50
C_2—Tractor plough 10·0″ depth disc and grubbing.	741·0	361·58	529·9	317·54	500·16
'F' test	Not Sig.	Not Sig.	Not Sig.	Not Sig.	Sig.
S. Em.	±38·9	±16·67	±21·2	±8·93	±5·36
C.D. at 5 per cent	..	..	..	..	21·02
(V) *Varieties*—					
V_1—Co 312	730·16	364·07	480·70	321·01	399·59
V_2—Co 453	754·49	382·17	531·60	306·33	597·05
'F' Test	Not Sig.	Not Sig.	Sig.	Not Sig.	Sig.
S Em	±32·8	±11·69	..	±7·72	±5·80
C.D. at 1 per cent	..	..	26·3	..	30·43
(N) Nitrogen dozes—					
N_0—No Nitrogen	604·46	372·16	461·0	312·51	458·43
N_1—Am. sulphate at 80 lbs. N per acre.	812·09	373·06	527·1	313·09	515·62
N_2—Do. at 160 N per acre	812·62	384·14	528·80	313·79	520·86
'F' Test	Sig.	Not Sig.	Sig.	Not Sig.	Sig.
S. Em.	+17·25	+8·09	..	±6·73	±8·33
C.D. at 1 per cent	69·77	..	38·7	..	31·38
(P) Phosphate dozes—					
P_0—No Super	722·72	369·16	506·0	306·0	493·67
P_1—Super at 80 lbs. P_2O_5 ac.	761·95	377·08	505·9	319·54	502·92
'F' Test	Sig.	Not Sig.	Not Sig.	Not Sig.	Not Sig.
S. Em	±12·0	±6·77	±8·35	±5·49	±7·37
C.D. at 5 per cent	38·60	..	..	..	..

Above results indicate that the cultivation with country plough is the optimum for Sugarcane. As a plant cane, variety Co 453, is indicated to be better than Co 312 and 80 lbs. nitrogen ammonium Sulphate is the optimum. There is no residual effect of nitrogen applied to plant cane. Applicantion of P_2O_5 is not necessary under the conditions of the experiment.

(iii) *Cultural experiment on Cotton* (*Cultivation, Nitrogen & placement*).—The results are given below :

Treatments.	Yield of seed cotton in mds. per acre.
C_1—Tractor cultivation 10″ deep (with inversion)	18·41
C_2—Bullock cultivation with inversion 4·5″ deep.	21·04
C_3—Bullock cultivation without inversion 4·5″ deep	22·04
'F' Test	Sig.
S. Em.	+0·566
C.D. at 1 per cent.	2·93
Sub plot (1st Split)	
P—Placement	21·14
T—Top dressing	20·01
'F' Test	Not Sig.
S. Em.	±0·301
C.D. at 5 per cent	1·101
(*2nd Split*)	
1. Am. sulphate at 40 lbs. N per acre	19·53
2. Ground nut cake Do.	21·27
3. Am Sulphate at 40 lbs. N+Super at 80 lbs P_2O_5/acre	20·00
4. Ground nut cake at 40 lbs. N +Super at 80 lbs. P_2O_5	21·50
'F' Test	Sig.
S. Em.	±0·294
C.D. at 1 per cent.	1·167

Results indicate that the cultivation with country plough (treatment C_3) is the optimum for cotton. Placement is just significant over top dressing. Application of nitrogen in the form of Groundnut cake is better than ammonium sulphate. Addition of P_2O_5 has no advantage.

(iv) *Tillage experiment on wheat* (Number of ploughings, weeding and manuring) —The summary of results is as under :

Treatment.	Yield of wheat grain in mds. per acre.
Main plots.	
A. 3 ploughings with 'desi' plough	18·13
B. 6 ploughings with 'desi' plough	20·15
C. 9 ploughings with 'desi' plough	23·05
D. 12 ploughings with 'desi' plough	24·31
S. Em.	±0·439
C.D. at 5 per cent	1·22
Sub plot (1st split)	
N_0—No Nitrogen	20·07
N_1—40 lbs. Nitrogen as sulphate of ammonia per ac.	22·87
S. Em.	±0·878
Sub plot (Second split).	
Wo—No weeding	21·06
W_1—One weeding	21·79
W_2—Two weedings	21·57
S. Em.	+3·889

Nine cultivations are the optimum number of cultivation for wheat. This is in agreement with the findings of the previous year.

(v) *Cultural experiment of Cotton* (*Sowing dates* : *varieties and spacing*).—The summary of results is given below :

Treatment.	Yield of seed cotton in mds. per acre.
Main plot.	
D. Sowing Date.	
D_1—25th April	20·19
D_2—10th May	15·30
D_3—25th May	15·36
D_4—10th July	11·20
'F' Test	Sig.
C.D. at 5 per cent	2·836

Treatment.	Yield of seed cotton in mds. per acre.
Sub Plot (1st Split). Varieties (V).	
V_1—F-216	16·93
V_2—F-320	16·64
V_3—M-4	14·33
V_4 L.S.S.	14·90
'F' Test	Sig.
C.D. at 5 per cent	1·805
Sub plot (2nd split).	
S—*Spacing*—	
S_1—2 ft.	17·04
S_2—2½ ft.	15·75
S_3—3 ft.	14·55
'F' Test	Sig.
C.D. at 5 per cent	2·476

Results indicate that the optimum range of sowing period lies between end of April to end of May. Two feet spacing between the rows appears to be optimum. Varieties F-216 & F-320 have done better than M-4 or L.S.S.

(vi) *Cultural experiment on Jute* (*Sowing dates and varieties*).—The summary of the results is given below :

Treatments.	Yield of fibre in mds./acre.
Main plot. D. Sowing dates.	
D_1—25th March	20·25
D_2—15th April	19·36
D_3—5th May	22·66
D_4—25th May	20·13
'F' Test	Not Sig.
S. Em.	±1·88
Sub-plot. Varieties (V).	
V_1—0-40-753	25·94
V_2—0-154	15·23
'F' Test	Sig.
C.D. at 5 per cent	8.46

Results indicate that the sowing of Jute could be spread from end March to end May at Delhi without loss in yield. Variety 0-40-753 is better suited to Delhi conditions.

vii. *Placement of fertilizers with Peas.*—The experiment was conducted for two years. There was no response with the application of P_2O_5. Broadcasting of fertilizers did not show any better performance than the placement method.

viii. *Seed rate-cum-varietal-cum-manurial experiment on wheat.*—The different seed rates varying from 50 to 110 at the interval of 15 lbs. did not show any significant differences. The interaction between seed rates, manures and varieties did not show significant difference. This is in conformity with the findings of previous years.

ix. *Cultural experiment on wheat (Seed rates, weedicide and nitrogen).*—The different seed rates 50, 75 and 100 lbs. per acre did not show any significant differences. Use of 2-4-D weedicide did not reveal any difference in yields. The nitrogen application gave significantly higher yield but interactions were not significant.

C. Rotational Experiments

Rotational experiments have been started in 1951 with a view to studying the effect of : (1) Different intensities, (2) Fallow, (3) Legumes, (4) Green manure and (5) Sequence of crops. It is a long term experiment and first set of results will be available after 3 years. *Mixed cropping* experiments are in progress to study the suitable mixture of crops, their method of sowing and ratios in which seeds of different crops to be mixed.

D. Varietal Trials

i. *Varietal trial with chillies.*—A varietal trial with 12 varieties of Chillies indicated that variety N. P. 5-1-5 gave the highest yield of 48 mds. of dry chillies per acre and appears to be the most suitable variety.

ii. *Varietal trial with cotton.*—Summary of the results is given below :—

	A	B	C	D	E	F	G	H	'F' test	C.D. at 5 per cent
Varieties . .	M-4	F-216	F-216/3	F-216/14	F-23	F-100	MAV	BC-68	Sig	1·39
Yield of seed cotton in mds./ac.	16·15	17·00	15·81	16·41	13·73	14 56	15·42	12·31		

Varieties F-216, F-216/14 and M-4 are equally good so far as yield is concerned.

iii. *Varietal trial with maize hybrids.*—The summary of the results is given below :—

	A	B	C	D	E	F
Variety . .	Meerut-yellow	Dixie 11	Indiana 252	U-513	N.C. 27	Texas 26.
Yield of maize grain in mds./ac.	20·51	27·61	15·16	26·53	29·36	27·22

	G	H	I	J	K	L	'F'	C.D.
Variety . .	Dixie 33	Dixie 22	K-T-41	Dixie 18	Georgia 281	P.Y. No 2 (Control).	Test. Sig.	at 1% 7·07
Yield of maize in mds./acre.	33·73	29·36	24·88	27·41	22·74	21·87		

Dixie strains of hybrids have shown better performance.

E. Irrigation experiments

Experiments are now in progress to study the relationship of irrigation, varieties and nitrogen in case of wheat ; cultivation, nitrogen and irrigation in case of sugarcane ; depth of furrow in case of potato. Results will be available during next 2 years.

F. Agrostology

i. *Grasses and legume collection.*—Four grasses and five legumes from Assam were added to the nursery making a total of 177. Some of the promising grasses and legumes were as under :—

Grasses (*a*). *Urochloa mosaubiencensis and Urochloa Sp.* from Australia were multiplied in 1/60 th of acre each. They yielded 510 mds. in 2 cuttings and 640 mds. in 3 cuttings. per acre respectively. Both the grasses were highly relished by the cattle.

(*b*). *Bracharia species :* Bracharia brizanthia was found fairly drought and cold resistant. It yielded 210 mds. in one cutting per acre.

(*c*). Amongst new collections P. padicellatum and natal grass (Trich : Resea) showed promise.

ii. *Legumes.*—(*a*). *Mucuna cochinchinensis.*—Yield 180 md. of green fodder per acre. This legume remains green till end of November. It is rich in protein containing 20·31 per cent. It is relished by cattle. It is useful for growing in mixture with maize for fodder. When grown in mixture with maize, the mixture gave higher yields than maize and cowpea mixture.

(*b*) Carpet legume (*Dolichos Lablab*). It is good for soil conservation and its protein content is 27·68 per cent.

(*c*) Among new collections *Clitoria ternetra* collected from Assam showed promise.

Ley Farming experiment.—Unmanured wheat crop following the ley period of one, two and three years, gave significantly more yield than the continuous cereal rotation.

In case of one or two years ley duration *cenchrus* plots showed higher yields of cereal crop immediately after the ley period, when compared to *Dichanthium* and Rhodes grasses. In case of three years duration, both *Dichanthium* and Rhodes grasses gave better results than *cenchrus*. This indicates that the introduction of *cenchrus* is likely to prove better for short ley periods and *Dichanthium* and Rhodes grasses would likely do better for longer ley peroids.

Soyabean varietal trial for fodder.—Of the four varieties received from the Division of Botany, variety IC-212 gave the highest yield of fodder during the last two years. The yield was of the nature of 120 maunds of green fodder per acre.

Phosphate manuring of Hubam clover.—Manuring with 40 to 50 lbs. P_2O_5 significantly increased the yield of green fodder.

Maize following Hubam clover grown for seed, fodder and green-manure and manured with 4 levels of phosphate, did not show significant results.

G. Cattle Breeding and Management

The strength of the herd at the close of the year was 54 heads against 51 heads at the beginning of the year. Six male stock were transferred to Karnal.

Milk yield.—The wet and overall averages as recorded during the year were 25·7 lbs. and 15·6 lbs. per cow per day respectively as against 22·5 lbs. and 13·5 lbs. recorded last year. The highest wet average recorded was 29·7 lbs. in the month of April.

Calf Rearing.—11 male and 6 female calves were born during the year. Their average birth weights were 49·2 lbs. and 56·5 lbs. respectively. The growth rates of pail-fed calves were as follows :

Male calves (up to 6 months)—1·30 lbs. per day. Female calves (upto 9 months) —1·20 per day.

Early Maturity.—The performance of early maturity heifers who completed their lactation was as under :—

Description.	No.	Average age at 1st calving.			Average milk yield per lactation.		
		Year	month	days	I	II	III
First calvers	3	2	9	0	7,775	..	..
Second calvers	1	2	5	22	5,296	8,156	..
Third calvers	3	2	5	..	6,799	6,323	7,343

H. Collaborative Research

The experiments on the comparative value of chilean nitrate with ammonium sulphate as control are in progress in several States in the Union since 1951 on different crops, *viz.*, wheat, paddy, cotton, sugarcane and other important crops of the locality. The number of experiments has considerably increased during 1953. The work is being conducted both on the Government Farms and Research Stations, Cultivators' fields and in some Community Projects, on a uniform plan sent from here, with local modifications where necessary. The experiment was being conducted in about 30 centres during 1952-53.

Report on the trials in 1951-52 was sent to Government during the year. Second lot of 100 tons of Chilean Nitrate as free gift was received from Messrs. Nitrate Corporation of Chile Ltd., London, during the close of the financial year for conduct of experiment in 1953-54. Distribution to various States remained in progress.

2. Collaborative experiments on Kudzuvine, grasses and legumes are also in progress in different States as under : A trial of Kudzuvine in 11 centres and trial of grasses and legumes in 13 centres.

IV. Agricultural Economics

There is only one Research Assistant in this Section. He is engaged on working out the cost of milk, crops, irrigation and tractors.

V. Intensive Cultivation Scheme

During 1950, work on the intensive cultivation scheme was started in 19 villages selected round about Indian Agricultural Research Institute. The work was continued. The main items of work were :—

1. Conduct of demonstration plots showing —1. improved seeds, 2. improved methods of cultivation, 3. use of manures and fertilizers, 4. use of implements and 5. introduction of new crops, etc.
2. Seed distribution.
3. Control of diseases and pests, 4. land army work and 5. tree plantation.

VI. Seed Supply

During the year the following supplies of improved seeds were made :—

Crop	Quantity Mds.
Wheat	138-20
Oats	87-16
Barley	31-14
Maize	16-16
Other crops	12-0
Grasses and legumes	407 seed samples were sent.

	Plants	Seeds	Crowns
Kudzu	18	215	744

VII. Yield of Crops

The yields of the important crops grown in the Division of Agronomy at Indian Agricultural Research Institute, New Delhi during 1952-53 were as under :—

Crop	Total area	Yield per acre	Remark
Wheat	75·24	18·95	Highest yield of 40 maunds per acre was recorded from an area of 1·0 acre.
Oats	59·75	18·6	
Barley	5·77	26·6	
Peas	23·88	11·3	
Berseem (fodder)	33·59	571·9	
Cotton	9·93	12·21	
Maize	29·25	12·1	
Maize & Cowpea (fodder)	21·18	250·9	
Jowar (fodder)	53·8	189·93	
Potato	3·64	205·3	Highest yield of 600 maunds per acre was recorded from an area of 0·17 acre.

VIII. Schemes

During the year the following schemes were in progress :

i. *Kudzuvine Scheme.*—This was closed on 1-4-53. The important findings of the working of the scheme were : (*a*) That the best method of propagation of Kudzuvine is through vegetative method of propagation. Planting of Kudzu crowns during December-February has been successful.

(*b*) Out of the four indigenous species of Puereria, only P. hirsuta from Assam was found to be promising being winter-hardy.

ii. *Key Farm Scheme for Live Stock improvement.*—The work on this scheme could not be commenced as requisite staff could not be appointed.

iii. *The collection of Pasture Grasses and Legumes, their testing and distribution and their breeding for better agronomic characters.*—One Research Assistant was appointed by February, 1953. The other staff could not be appointed. There was, therefore, hardly any progress of work during the year.

iv. Scheme on the Agronomic Studies on Sesamum and Linseed financed by the Indian Central Oil Seeds Committee was in progress. The work on the varietal trials, mixed cropping and manuring remained in progress.

IX. Agricultural Research Substation, Karnal

The main items of work at this Substation are :—agronomic research and seed multiplication. The main items of research are manurial, cultural, varietal experiments and long term experiments on tillage, holdings, etc. Paddy and wheat are the two important crops on which the research work is concentrated. The results of some of the imporant experiments are given below.

Manurial Experiments

1. *Manuring of paddy in Paddy-wheat rotation.*—The manuring treatments were as under :—

Nitrogen (N)	N_0	N_1	N_2
As ammonium sulphate	*Nil*	30 lbs.	60 lbs.
P_2O_5 (P)	P_0	P_1	P_2
As Superphosphate	*Nil*	60	120
K_2O (K)	K_0	K_1	..
As Potash	*Nil*	80	..

The fertilizers are applied every year to paddy. The results indicate that there was response with nitrogen only. The dose of 60 lbs., 30 lbs. and control gave the yields of 25·4, 22·8 and 19·6 maunds per acre respectively. The differences between different doses and control were significant. There was no response with either P_2O_5 or K_2O.

2. *Green manuring of paddy in conjunction with fertilizer.*—Dhaincha was used as green manure crop with and without 60 lbs. P_2O_5. Nitrogen at the the rate of 20 and 40 lbs. per acre was applied to paddy sown after green manure. Green manuring was found significantly superior to no green manure. Phosphate did not show any effect. The application of nitrogen in the form of ammonium sulphate also did not show any significant increase.

3. *Paddy nursery manuring experiment.*—There was no effect of manuring of paddy in nursery on the transplanted crop of paddy grown without manure.

Cultural experiments

(i) *Tillage of wheat in conjunction with manuring with Farmyard manure and ammonium sulphate.*—The different cultural treatments, *viz.*, tractor plough, bullock drawn inversion plough and country plough, gave 16·81, 16·95 and 16·37 maunds per acre respectively. There was thus no difference due to cultural treatments. Amongst the manurial treatments ammonium sulphate gave the highest yield followed by ammonium sulphate *plus* F.Y.M., farmyard manure alone and no manure. The results are in agreement with the findings of the previous years.

(ii) *Tillage of wheat in conjunction with green manure and fertilizers.*—The cultural treatments of tractor plough and bullock drawn inversion plough gave yield of 18·86 and 18·72 maunds of wheat per acre, indicating that both the treatments are equal. Amongst the fertilizer treatment, the application of P_2O_5 to green manure did not show any advantage over no P_2O_5. Nitrogen alone or in combination with P_2O_5 applied to wheat showed better results than control. These findings are in agreement with results of previous years.

Varietal experiments

(i) *Wheat varietal trial.*—The results are as under:

Variety	N.P. 718	N.P. 781	N.P. 720	N.P. 721	C-518	P.C. 36	N.P. 775
Yield in mds./ac.	28·70	27·50	26·69	26·58	26·52	23·81	23·64
Variety	N.P. 798	N.P. 796	N.P. 797	N.P. 715	N.P. 760	C-591	N.P. 710
Yield in mds./ac.	23·10	22·94	22·72	21·47	25·87	25·71	24·46
S. Em.	±0·96	..	..	..	..	..	..
C.D. at 5 per cent	2·67	..	..	..	..	..	..

Results indicate that N.P. 718 gives the highest yield per acre. However, N.P. 718, 781, 720, 721 and C-518 do not show significant differences.

(ii) *Jowar varietal trial.*—Amongst the varieties tested varieties J. C. 20 and 21 from the Punjab gave nearly equal yield of 290 maunds of green fodder per acre.

Cultivators' holdings.—The results of the sixth year have been recorded and the overall picture is now under study.

Seed supply.—During the year 338·06 maunds of various seeds were distributed as under:

Paddy	Maize	Wheat	Barley	Misc. crops
Mds.	Mds.	Mds.	Mds.	Mds.
37·18	7·25	251·81	21·0	20·82

PROGRAMME OF WORK FOR 1953-54.

A. Manurial experiments

i. *Nitrogenous manures and fertilizers.*—Experiments to test the relative values of nitrogen in organic and inorganic manures and also response of their combination on various crops. Experiments to determine optimum time for the application of Farm Yard Manure and nitrogenous fertilizer.

ii. *Phosphatic fertilizers.*—Experiments with different forms of phosphatic fertilizers to study their response.

iii. *Nitrogenous and phosphatic fertilizers.*—Experiments to study the effect of these, each at different levels and in combination on the yield of crops.

iv. *Green manures.*—Choice of legumes for green manuring optimum time of burying in S. Hemp for green manuring, green manuring experiment with 'guar' conjunction with micronutrients, economics of green manuring.

v. Manurial-cum-cultural experiments with various crops involving studies on manuring in relation to sowing dates, seed rates, time of application and placement.

vi. Micronutrient studies.

vii. Permanent and new manurial experiments at Pusa under rainfed conditions.

B. Cultural experiments

i. Tillage experiments with different crops.

ii. Sowing dates, placement, weedicides, seed rates and spacing experiments with various crops.

C. Rotations

i. To study the effect of different intensities, legumes, fallow and sequence of cropping.

ii. Mixed cropping.—To find out suitable mixtures, their method of sowings and ratios in which different crops to be mixed.

D. Varietal trials

Experiments will be conducted with improved varieties of different crops.

E. Irrigations

i. Experiment to study the relationship of irrigation, variety and nitrogen in case of wheat. ii. Irrigation, cultivation and nitrogen in case of sugarcane. iii. Irrigation, depth of furrow and fertilizers in case of Potato.

F. Agrostology

To produce high yielding and palatable fodder grasses and legumes for cattle, increase the productivity of natural grassland, to work out suitable seed mixtures of grasses and legumes for pastures, to evolve a suitable system of ley farming, maintenance of nursery.

G. Collaborative research in States on grasses and legumes and Chilean Nitrate.

H. Experiments in connection with Technical Co-operation Administration.

I. Cattle breeding and management. It will include work on :—

i. Line breeding and selection for improvement in milk yield.

ii. Feeding of stock on balanced rations for growth, early maturity and high milk yield.

J.-I. A. R. I. Intensive cultivation Scheme

The intensification work in 19 villages around Delhi State will be continued.

REPORT OF THE DIVISION OF BOTANY (INCLUDING BOTANICAL SUB-STATION, PUSA) FOR THE YEAR 1952-53

(Dr. R. D. Asana)

The resarch activities of this Division were continued under the four sections comprising it. The section of Plant Breeding and Genetics dealt with basic problems such as breeding for disease resistance and also the evolution of improved varieties of crop plants and their trial in the different states of India. The Section of Cytology and Cytogenetics concerned itself with experiments on the improvement of cytological technique to enable critical study of chromosomes, which are the principal bearers of heredity ; on the economic possibilities of doubling of chromosomes in crop plants and on chromosome behaviour, in relation to inheritance of characters, in species and species hybrids of crop plants. In the Section of Plant Physiology, researches were carried out, especially in relation to the wheat crop, on resistance to drought and to lodging, crop nutrition, physiological analysis of factors influencing crop yield and on the role of chemical growth-regulating substances in plant growth and development and their use as weed-killers. The Section of Plant Introduction, Economic Botany and Systematic Botany was engaged on the introduction of varieties of crop plants and their allied species and genera from foreign countries and on their study and trials within the country ; the survey of weed succession in the crop fields of the Division was also undertaken and additions were made to the herbarium.

The Division collaborated with the different State departments of agriculture and other agricultural research institutions in India and abroad and with international organisations like the F.A.O. and exchanged useful scientific information and plant material. A considerable volume of advisory work was also attended to.

The following is a summary of the work done and results obtained during the year under report.

Plant Breeding and Genetics

1. *Breeding wheat varieties for resistance to the rusts.*—The work on breeding for rust resistance, being carried out at Delhi and at the substations located at Simla, Pusa (Bihar) and Indore, was further intensified and co-ordinated. A large number of indigenous and exotic wheat varieties, including the many introductions made recently, were critically evaluated with regard to rust-resistance and desirable agronomic characters. Suitable among these have been utilised in an integrated breeding programme which aims at incorporating into single varieties resistance to rust from as diverse parental sources as possible.

With the help of the Division of Mycology, over 1,100 cultures, comprising indigenous and exotic varieties and selections made in the different segregating generations of large numbers of hybrid progenies were tested, in the seedling states for rust resistance. The tested seedlings from the segregating hybrid progenies

were transplanted into the field and tested, under conditions of artificial inoculation of the rusts, for resistance at the adult stage of the plant ; a number of other cultures were tested in a similar manner for their reaction to rusts at the adult stage of the plant only. Detailed observations were recorded on the rust reaction and agronomic characters of plants in these materials. Similar work was done at Simla, Pusa and Indore also. Based on these observations, about 1,000 promising selections have been made at these centres. A number of cultures in the final stage of selection were grown at Delhi and Simla for performance tests ; many of them appear to be very promising.

Among the varieties tested for rust resistance, N.P. 789 and N.P. 790 proved resistant to all the prevalent races of black rust including the biotypes, 15-C and 42-B. The Australian variety, Ridley (E. 572), which has done very well in the northern hills of India, was susceptible only to the biotype, 15-C, of black rust. E. 952 was resistant to all the prevalent races of brown rust and to eight out of ten races of yellow rust. Among the material recently received from the U.S.A., E. 1913 and E. 1951 were found to be resistant to all the Indian races of black rust, including the two biotypes 15-C and 42-B, and E. 2140 and E. 2143 were resistant to all the prevalent races of brown rust.

Yield trials.—A number of varieties belonging to the "700-series", recently evolved in this Division, were under trial at about 25 centres in India. At Sambalpur (Orissa), N.P. 775 and N.P. 737 gave outstanding results. In Madhya Bharat, N.P. 710,720, 760 and 764 and in Saurashtra, N.P. 710, 715, 758 and 798 were among the best performers. In Himachal Pradesh and at some centres, such as Kulu and Nagrota, in the Punjab Hills, N.P. 770, N.P. 809 and Ridley (E. 572) gave very good yields ; N.P. 770 and Ridley (E. 572) were found to be superior to the improved hill varieties, Pb. C. 224 and Pb. C. 250, evolved by the Punjab Department of Agriculture. At Pusa (Bihar), N.P. 799 and N.P. 798 gave the best results ; the improved variety, B.R. 319, evolved by the Bihar Department of Agriculture, was found to be poor in yield and was also highly susceptible to the rusts. The Uttar Pradesh Department of Agriculture has decided to replace Pb. C. 591, which was one of its standard varieties so far, by N.P. 710. Seeds of the varieties, N.P. 710, 718, 775 and 761 are in great demand. In the northern hills, N.P. 770 continues to be in heavy demand , particularly in Himachal Pradesh.

Chapatee-making tests.—A number of the important N.P. wheat varieties were tested, along with Pb. C. 591, for their *chapatee-making* qualities. Some of them, especially N.P. 775, N.P. 781 and N.P. 758, appeared to be superior to Pb. C. 591.

World Catalogue of Genetic Stocks of Wheat.—In connection with this work, which is being done in collaboration with the F.A.O., 107 indigenous varieties were grown in a replicated trial for the study of yield, reactions to the rusts and a number of botanical and agronomic characters.

2. *Breeding of rust-resistant and early-maturing strains of linseed.*—A large number of the newly-evolved, early-maturing, rust-resistant strains and segregating hybrid progenies of crosses involving some of the new and older rust resistant strains and an exotic variety, Bolley Golden, were tested for resistance under artificial inoculation of rust in the field. Many of the new, early-maturing strains again proved to be rust-resistant and, in the segregating hybrid progenies, a number of

promising selections were made on the basis of rust resistance, early-maturity good tillering and bearing of medium-to-large-sized furits. Further selections were made in the F_3 generation of crosses involving the varieties, Bolley Golden and Afghanistan 2, for early maturity, high tiller number and high yield. Selections were also made in the F_4 generation of crosses, involving the flax variety, Wada, as one of the parents, for producing dual-purpose strains which could be used both for seed and for fibre.

In an yield trial laid out with 13 of the older series of rust resistant strains evolved in this Division a few years ago, the strains N.P.R.R. 10, 38, 67, 204 and 272 significantly outyielded the controls, N.P. 12, E.B. 3 (from Madhya Pradesh$_5$) and the U.P. strains 1193-2 and 477. Similar trials were held at a number of centres in eight states of India. At Hoshangabad, the results indicated the superiority, in respect of yield and rust resistance, of two of the newly-evolved rust resistant strains over E. B. 3, the best improved variety of that tract; the trial will be repeated next year to confirm these results. Results from the other centres of trial are awaited.

Twelve dual-purpose strains bred from linseed-flax crosses were tested at Delhi for their performance; the salient results are summarised below :—

Variety or strain	Average yield of seed per replication	Average yield of straw per replication
	lb. oz.	lb. oz.
Flax J.W.S.	1 4½	6 5
Flax Tall	1 2½	9 3½
N.P. 12	2 8	2 14¼
Flax Tall×N.P. 124 (6)	2 6¾	4 15½
Flax Tall×N.P. 124 (9)	2 4¾	5 9

A significant observation was made in respect of K. 2, a rust resistant strain claimed to have been evolved by the Punjab Department of Agriculture. Compared with the strain, N.P.R.R. 9, evolved at this Division, K. 2 appeared to be identical with N.P.R.R. 9 in respect of maturity, plant habit and height, tillering, colour in floral organs and seed, petal form, size and shape of boll, nature of septa, size and weight of seeds and rust resistance. The Economic Botanist (Oilseeds), Uttar Pradesh, also observed that N.P.R.R. 9 and K. 2 were both highly resistant to wilt. These observations leave little doubt that K. 2 and N.P.R.R. 9 are one and the same.

3. *Safflower.*—A number of varieties of cultivated safflower (*Carthamus tinctorius*, 2n=24) and *C. oxyacantha* (2n=24) and a strain each of *C. coeruleus* (2n=24) and *C. lanatus* (2n=64) were under observation. While most of the varieties of *C. tinctorius* and all of *C. oxyacantha* were badly affected by safflower rust (*Puccinia carthami*) and *Cercospora carthami*, *C. lanatus* and *C. coeruleus* remained completely free from both the diseases and four strains (804-21, 804-21A, 852 and 514-2-10) of *C. tinctorius* from Nebraska (U.S.A.) showed little infection by both the diseases, particularly the rust.

In a replicated yield trial at Delhi, some of the above Nebraska strains gave outstanding results in respect of yield and oil content ; the estimation of the latter was done by the Division of Chemistry. The salient results are briefly given below :—

Variety or strains	Average yield of seed per replication	Oil content	1,000-seed weight
	lb. oz.	per cent.	gm.
Nebraska 804-21	11 13¾	33·70	48·25
Nebraska 852	9 12¾	36·70	46·00
Gadag 2-10-1 (Bombay)	7 5½	29·90	51·05
Niphad 6-30 (Bombay)	6 2½	32·25	47·00
N.P. 1	4 13½	33·30	53·05
N. 7 (Madhya Pradesh)	4 5½	31·10	58·25

The promising among the Nebraska strains were also under trial at a number of centres in India ; the results are awaited.

4. *Pigeon Pea.*—Tests carried out for resistance to the wilt disease, caused by *Fusarium udum*, confirmed last year's results regarding the high resistance of some of the N. P. types and hybrid selections and of a type obtained from Burma. In yield trials conducted at Delhi and Pusa, the wilt-resistant strains—C. 15 (Pusa) and C. 15 (W. E.), outyielded the controls, N. P. 41 and N. P. 80. In a trial at Arbhavi (Bombay State), F. 52—a variety from one of the states, showed 91·17 per cent resistance to wilt and the strain C. 15 (W. E.) evolved at this Division stood second showing 89·37 per cent resistance ; the yield data from this trial are awaited.

5. *Chilli.*—In a yield trial of some pungent varieties conducted at this Division, the varieties N. P. 46A (1949 lb./acre) and N. P. Hyb. 5-1-5 (1922 lbs./acre) did very well, the Delhi Local giving only 1,164 lbs./acre ; among the non-pungent varieties, the variety World Beater gave the best yield (12,841 lb./acre) of green fruit and it was followed by R. 449 (10,458 lb./acre) and R. 619 (10,027 lb./acre). In a trial conducted at the Division of Agronomy, the pungent varieties—N. P. Hyb. 5-1-5 and N. P. 46, significantly outyielded all the others ; among the non-pungent varieties, R. 619 stood first and was followed by R. 449, World Beater and Bell Pepper.

6. *Tobacco.*—Two replicated trials were conducted. In both of them, the new hybrid selections of *Nicotiana rustica* outyielded the control, N. P. 18 ; this year, S. 19 stood first, S. 22 second and S. 20 came third in order of performance.

7. *Tomato.*—A large collection of indigenous and foreign varieties, including a number of new introductions, were grown for evaluation of their potentialities. The variety, Meeruti, among the indigenous, and Sioux among the exotics remained the best performers. Although the latter variety gives high yields of fruits of good quality, it does not appear to be as hardy as Meeruti, which is the hardiest. Crosses between these varieties had therefore been made and this year, some very promising selections have been made.

Among the recent introductions, the variety, Pearl Harbour, appears to be useful for summer planting owing to its dense foliage which protects the fruits from sun-burn.

The results of chemical analyses of fruits done by the Division of Chemistry are summarised below :—

Variety.	Vitamin-C content (mg/100 gms. of sample).	Total sugars. (%)	Carotene content. (p.p.m.)
Lycopersicon esculentum—			
Sioux	36·4	3·07	4·0
Meeruti	30·8	3·23	6·8
Prosperity	30·5	1·98	4·0
Hyb. 3	43·0	3·23	6·6
Hyb. 6			
(*a*) Ripe fruits from staked plants	52·2	4·94	20·4
(*b*) Ripe fruits from unstaked plants	43·4	4·25	..
Lycopersicon pimpinellifolium	60·5	3·31	15·7

With a view to utilising hybrid vigour in tomato for increasing crop production, a number of hybrid conbinations were under study. The results indicate that the crosses, Sioux × Meeruti and Sioux × Prosperity, exhibit an appreciable degree of hybrid vigour.

8. *Breeding bhindi* (*Abelmoschus esculentus*) *for resistance to mosaic disease.*—During what appeared to be a heavy natural incidence of mosaic on *bhindi* this year, five indigenous varieties appeared to be highly resistant ; it is, however, likely that they behaved as 'carriers' of the disease without showing visible symptoms. Attempts were being made to utilise them in the breeding programme ; the related species, such as *A. ficulneus*, *A. tuberculatus*, *A. pungens* and *A. manihot*, which are also resistant to mosaic were also sought to be utilised in breeding.

9. *Hybrid vigour in radish* (*Raphanus sativus*).—A number of hybrid combinations in this self-incompatible root crop exhibited appreciable hybrid vigour ; thus in a cross between a local variety and a Chinese variety, T. 383, the hybrid gave 42 to 50 per cent greater yield (in weight) of roots as compared with the parental varieties. A number of methods of planting were being tried with a view to obtaining the maximum possible amounts of hybrid seed from natural pollination of the desired parental varieties.

10. *Hybrid Maize.*—This work is being done under a scheme financed by the I. C. A. R.

Yield trials.—In a trial at Delhi with 45 Indian and foreign varieties and some double-cross hybrids, the U. S. hybrid, N. C. 27, gave the highest yield (3,133 lbs./acre) and it was followed by an indigenous variety, Basi (2,643 lbs./acre), American Early Dent (2,420 lbs./acre) and the U. S. hybrid, Texas 26 (2,377 lbs./acre) ; all of these outyielded the other varieties, including the check, Pusa Yellow-2 and Meerut Yellow. In another trial with 95 varieties, N. C. 27 (3,932 lbs./acre) again topped the list and was followed by Pusa F (wh.) Pl. 2 (3,436 lbs./acre), Pusa Culture L. Pl. 2 (3,363 lbs./acre) and Jathia-D (3,061 lbs./acre) ; these varieties outyielded all the varieties used as checks.

A number of American maize hybrids were tested in small-scale trials at 18 centres and in large-scale trials at 13 centres in India. The results available so far show that the hybrids, N. C. 27 and Dixie 33, were the most outstanding. The increases in yield, over those of the best locals, given by the best among the hybrids ranged (*a*) from 31 per cent at Jullundur (Punjab) to 121 per cent at Elkurty

(Hyderabad) in the small-scale trials and (*b*) from 29 per cent (at Arbhavi, Bombay State) to 48 per cent (at Kanpur, Uttar Pradesh) in the large scale trials. N. C. 27 matured at about the same time as the local varieties, while Dixie 33 was a little late.

Inbreds of some of the promising U. S. hybrids have been received through the courtesy of the F. A. O. and the U. S. Department of Agriculture ; these are being multiplied for eventual utilisation in the production of single-crosses and double-crosses.

Production of inbred lines and their evaluation.—Out of a total of 596 inbreds grown during the year, about 200 were selected for further inbreeding.

Two hundred and thirty top crosses were produced for the study of general combining ability. To determine specific combining ability, 76 single-crosses and 24 double-crosses were made. Out of these, yield trials will be conducted next year with about 80 top crosses, 19 single-crosses and 20 double-crosses whose seeds are available in sufficient quantities.

In a study of the relative merits of selfing and sib-mating for the production of inbreds, 46 pairs of S_1 *vs* Sb_1 lines and 11 pairs of Sb_3 *vs* Sb_2 S_1 lines were compared ; the plants of the Sb_1 and Sb_3 lines were significantly taller and the Sb lines were superior to the S_1 lines in respect of length of ear and the number of good cobs per plant, the differences between the Sb_3 and Sb_2 S_1 lines with regard to these characters being insignificant.

Cytology and Cytogenetics.

Crop improvement through colchicine-induced autopolyploids.—The study of the induced autopolyploids of some oleiferous *Brassicae*, sesame and linseed was continued with special reference to the problem of seed-fertility in them. The autopolyploids of sesame (*Sesamum orientale*) showed no appreciable improvement in seed setting which was quite poor. In autotetraploid *toria* (*Brassica campestris* var. *toria*), in which *elite* bulk populations were being built up through isolation and selection according to the mass-pedigree selection method, selection over three seasons appeared to have remarkably increased the frequency of highly fertile plants in one of the *elite* populations. Embryological investigations in these tetraploids indicated that about 60 per cent of the total failure of seed setting in them was due to abnormalities during the early stages of megagametogenesis which resulted in a large proportion of the ovules, at the stage corresponding to *anthesis*, remaining abortive.

In linseed, the observations confirmed the previous years' findings that different diploid genotypes responded differently to induced polyploidy in respect of the changes brought about in characters like plant height, branching, bearing of capsules, seed fertility, etc. Preliminary embryological observations in these autotetroploids suggest that failure of fertilisation of a proportion of the ovules appears to be an important cause leading to low seed setting in them.

Cytogenetics of some interspecific hybrids of Triticum.—A large population of F3 *Triticum vulgare*, E. 65 (2n=42) ×T. *pyramidale*, E. 228 (2n=28) was studied with regard to the distribution of chromosome numbers and morphological characters, specially those of the ear. There were segregants in which it appeared that at

least some of the species distinguishing characters of *T. vulgare* had been transferred to *T. pyramidale* presumably through intergenomal chromosome pairing. A number of asynaptic plants also appeared in this progeny; the causes underlying their occurrence are under investigation.

The A_3 generation of amphiploid *Triticum dicoccum*—Khapli (2n=28)×*T. monococcum*-Einkorn (2n=14) was grown and studied. The amphiploid was more or less intermediate between the parental species in respect of maturity and a number of morphological characters, and 90·9 per cent. of plants in the progeny bred true to chromosome number (2n=42). The amphiploid was susceptible, at the seedling stage, to all the races of brown and yellow rusts, its susceptibility to brown rust having come from the *dicoccum* parent and to yellow rust from the *monococcum* parent; the amphiploid was semi-resistant to black rust. It has been crossed with suitable varieties of *T. vulgare* and T. *durum* for breeding purposes.

The other interspecific hybrids under study included amphiploid *T. timopheevi* (2n=28) × *T. durum* (2n=28), also termed *T. sovieticum* (2n=56), and amphiploid *T. timopheevi* (2n=28)× *T. monococcum* (2n=14), designated *T. timococcum* (2n=42).

Chromosome number of Abelmoschus tuberculatus Pal et Singh.—This new species, studied and described in this Division, was found to contain 2n=58 chromosomes, thus validating its ranking as a species distinct from the cultivated *bhindi* (*A. esculentus*, 2n=130).

A. tuberculatus has been observed to be resistant to the mosaic disease and to the insect borer to which cultivated bhindi is susceptible.

Improvement of plant cytological technique.—A detailed experiment was carried out for assessing the relative merits of a number of chemicals, such as alpha bromonaphthalene, 8-oxyquinoline, paradichlorobenzene, chloral hydrate coumarine and sulphanilamide, usually employed in pretreatment, prior to fixation, in the root-tip-squash method. A cytological technique, involving the use of combinations of these pretreatment-chemicals followed by fixation in chromic acid-osmic acid fixatives and staining by the Feulgen method, was evolved and standardised. Using this technique on cereals, some interesting information on the karyotype of a number of species of *Triticum*, especially *T. macha* (2n=42) and *T. monococcum* (2n=14), has been obtained. A technique was also developed for preparing mounts of mitosis in pollen grains of cereals for the study of their chromosome number and structure.

Plant Physiology.

1. *Study of Draught resistance in wheat.*—A field experiment was laid down with the same fifteen varieties as were tested last season. In the unirrigated plot soil moisture upto a depth of two feet was just a little above the wilting coefficient during the whole of January and half of February with the result that growth was much more restricted as compared to the control plot. From February onwards the temperature was abnormally high and the effect of atmospheric drought being common to both the plots, the yield differences were narrowed down, the overall reduction under the unirrigated plot amounting to 10% only. Unlike last year, the Australian varieties did not maintain their superiority over the other varieties.

Under irrigation, they were inferior to a few other varieties, which could probably be attributed to conditions of more severe atmospheric drought prevalent during the season (the Australian varieties ear later). Under unirrigated conditions these varieties fared relatively better and their performance was nearly equal to that of the other varieties. Taking the results of the two seasons into consideration it would appear that at least two Australian varieties, viz., Kendee, and Ridley (more particularly the latter), stand up to drought better than the other varieties.

In the pot-culture, three varieties, viz. N.P. 710, N.P. 798 and the sixth generation of the cross *Gabo* × *Niphad*, were tested for continuous intermittent drought and drought commencing from February onwards. Although the grain yields of the three varieties were more or less identical under normal water supply, N.P. 798 outyielded the other two under both types of drought. Among ear characters, only grain number per ear could account for the superiority of N.P. 798 under drought. Selections of individual plants from 'drought' treatments were also made on the basis of ear and grain number. Grains from low and high yielding plant will be sown separately next season with a view to seeing if the differences in performance persist in the next generation.

Partial regression analysis of the data from three experiments under pot-culture, carried out by the statistical section, indicated that during the three seasons, under normal water supply, ear number was the most potent factor contributing to yield, whereas under restricted water supply there was no such consistency ; in one season, ear number alone was the most potent, in another season, ear number and grain number were more potent and in the third, ear number, grain number and 1,000-grain weight were equally potent.

2. *Physiological analysis of factors concerned with yield.*—A pot experiment involving three mid-early varieties of wheat, viz. N. P. 710, Pb. C. 228 and Kendee, three sowing dates and two levels of nitrogen supply was undertaken with a view to seeing how far some of the characters, which distinguish these varieties, varied under different environmental conditions and how they affected yield. Varietal differences in spikelet number per ear and in 1,000-grains weight persisted under the different treatments rather more consistently than those in ear number and grain number per ear. Since ear number has such a dominant influence on yield, it would appear that the latter is much less controlled by the varietal factor than by the environment.

3. *Study of the influence of light and temperature.*—In an experiment involving three varieties of wheat, viz., N. P. 165, Baluchistan 16, and Punjab C. 591, and three sowing dates, viz., 30th October 1952, 18th November 1952 and 10th December 1952, it was again found in confirmity with previous observations that Baluchistan 16 performed poorly under late sowing. Observations on the rate of increase of dry matter in the ear and grain indicated that it declined much earlier in Baluchistan 16, under late sowing.

4. *Physiological aspects of plant nutrition.*—In an experiment involving three varieties of wheat viz., N. P. 165, N. P. 710 and N. P. 52 and three levels of nitrogen, viz., O, 20 and 40 lb. per acre, it was again confirmed that N. P. 710 absorbed much larger amount of nitrogen than the other two varieties, although grain yields were

the same. Analysis of the nitrogen content of the different plant parts is being carried out to see if its distribution within the plant body differs in any way in these varieties.

5. *Plant Hormones.*—An elaborate experiment under pot-culture with two varieties of wheat, namely N. P. 710 and Punjab C. 228 was undertaken to see the effect of synthetic plant hormones namely, beta indolylacetic acid alpha naphthylacetic acid, beta indolylbutyric acid and tri-iodobenzoic acid. These substances, in various concentrations, were sprayed on the plants as well as introduced through cut leaf-tips. All these substances, in different concentrations increased the grain yield of N. P. 710 significantly and substantially, whereas in the case of C. 228, only alpha naphthylacetic acid and beta indolylacetic acid proved effective. The character most favourably influenced was ear number.

It has been reported that by soaking wheat grains in dilute concentrations of 2, 4-D prior to sowing, growth and yield increased by about 29 per cent (Patil, S. S. Poona *Agr. Coll. Mag.*, 43, 7, 1952). Several combinations of treatments, involving time of soaking and concentration, were tried and the crop was grown with as well as without irrigation. Only under dry conditions was yield increased by one treatment combination, viz. soaking in 0·1 p. p. m. for 20 hours, but seeds soaked in water for a similar period gave an equally good yield.

Weed-control.—In two field experiments involving the comparison of hand-weeding and different doses of weedicides, Agroxone, sodium salt of 2, 4-D, ethyl ester of 2, 4-D, emulsified ethyl ester of 2, 4-D, emulsified as well as non-emulsified mixed ester of 2, 4-D, and 2, 4, 5, T, (free acid), and 2, 4-D triethanolamine salt, it was found that yields were not significantly improved either by hand-weeding or by weedicides, although the weed population was effectively checked by some weedicides. In both the fields, the weed population was sparse and this accounts very largely for the absence of effect of weeding.

Control of Carthamus oxyacantha (*wild safflower ; pohli*).—A specially sown plot was sprayed with different doses of weedicides, sodium salt of 2, 4-D, methoxone, ester of 2, 4-D and emulsified ester of 2, 4-5T, at two stages, viz. 57 days and 100 days, after sowing. On the whole, *Carthamus* appeared to be more susceptible at the latter stage (pre-flowering). The most effective weedicide was the emulsified ester of 2, 4, 5 T, at the rate of $\frac{1}{2}$ gallon per acre ; the next in effectiveness was 2, 4-D ester in a similar dose.

Control of Kharif *weeds in Maize.*—An experiment to see the effect of pre and post-emergence application of weedicides, sodium salt of 2, 4-D, ester of 2, 4-D and C M U on the *Kharif* weeds in maize was taken up. The growth of weeds which about two months after sowing, very largely consisted of *Cyperus rotundus* and *Cynodon dactylon* was depressed to some extent by pre-emergence application of sodium salt of 2, 4-D at the rate of 2 lbs. per acre and C M U at the rate of 1 lb. per acre, but one hand-weeding about a month after sowing proved equally effective. C M U had a depressing effect on the growth of maize as well. Due to soil heterogeneity arising from alkaline patches, the growth of maize was not uniform and the treatment effects were not significant. In view of the fact that as much as 2 lbs. 2, 4-D per acre was required to produce an effect equal to that of one hand-weeding, the latter method would appear to be more economical.

6. *Lodging in wheat.*—A complex field experiment involving three varieties of wheat, three levels of nitrogen and times of application was laid down to determine a suitable treatment combination for minimising lodging. Lodging decreased with decrease in the level of nitrogen as well as with delayed application of nitrogen. Application of nitrogen 70 days after sowing appeared to minimise lodging effectively. Early application of nitrogen increased the shoot/root ratio and intensified lodging. The best index of lodging seemed to be shoot/root ratio, which confirmed the previous findings.

Plant Introduction and Systematic Botany.

Plant Introduction.—This work is being done since 1946 under a nucleus organisation financed by the I.C.A.R.

During the year under report, 437 samples of seeds of varieties of crop plants, other plants and related species and genera were received from foreign countries, 420 samples of plants were collected from within the country and 705 samples of seeds of a wide variety of plants were supplied for trial or other experimental purposes to the different State departments of agriculture, universities and other scientific research institutions both at home and abroad. Planting material of the introductions, such as the sweet potato variety F. A. 17, the tomato varieties—Sioux and Prosperity, the vegetable cowpea variety—E. C. 455 A and others which had shown great promise during previous years, was further multiplied for conducting more extensive trials of them at different centres in India.

The sweet potato variety, F. A. 17, appeared to be widely adaptable in the country and performed very well at a number of centres in Delhi, U. P. and Bihar and at Bangalore in the south ; at Bangalore, it yielded 50 per cent more than the best local variety. At one of the farms of the Neoli Sugar Factory in Etah District (U. P.), F. A. 17 yielded 25 per cent and 100 per cent more than the local white and red varieties respectively. On chemical analysis, tubers of F. A. 17 were found to be rich in sugar, those of " Golden Skin Yam " outstanding in carotine content and the indigenous variety, " Talentia ", was rich in crude fat.

In the yield of green pods in relation to earliness, the American garden pea varieties, Early Badger and Sis×7-5, proved superior to the indigenous early varieties, Lucknow Boniya and Hoshiarpuri ; " Bonneville " and " Delwiche Commendo ", also from the U. S. A., are promising midseason varieties. Studied with regard to yield of green pods and grain and the percentage of shelling, Bonneville appeared to be the best among the varieties under observation.

In cowpea, the Canadian white-seeded, bush variety—"Dolique du Tonkin ", appeared to be a very suitable early variety for growing a summer crop for yield of both green pods for vegetable purposes and of grain. Unlike the *mung* type, T. 1, from Uttar Pradesh, the pods of this variety do not shatter and therefore the harvesting can be done in a single picking ; the green plants after harvest can either be fed to cattle or ploughed in for green manuring.

As a result of trials of a large number of indigenous and exotic collections, a list has been finalised of the best varieties of vegetable crops, such as tomato, peas, bottle gourd, smooth gourd, *bhindi*, cluster beans, onions, etc.

Among the collections of miscellaneous plants, mention may be made of the following : the salt-resistant grass, *Paspalum vaginatum*, from Australia which established satisfactorily on being transplanted in a field affected by salinity ; three perennial species of *Zoisia* grasses, *Z. japonica*, *Z. tenuifolia* and *Z. matrella*, from the U. S. A. which are known for their turf-forming habit ; the fodder tree, Carob Bean (*Ceratonia siligua*), known for its long leathery pods which are relished by cattle ; Kudzu-23, a newly-evolved, quick-growing kudzu from the U. S. A., reported to be superior to the common kudzu ; a creeping variety of alfalfa from America which is considered to be suitable for areas having low rainfall ; ' Naranjilla ' (*Solanum quitoense*), a South American bush, the fruits of which yield a delicious and refreshing drink and ' New Hampshire Midget '—a small-fruited variety of high quality water melon from the U. S. A.

Systematic Botany.

Herbarium.—About 1,100 plant specimens were added to the herbarium during the year, the total items numbering about 5,000. The herbarium has been registered in the International Index of Herbaria (1952) published by the International Bureau of Plant Taxonomy and Nomenclature, Utrecht, Netherlands.

Variation in the varieties of crop plants.—The investigation on the range of variation in jute varieties was continued. At Pusa, the variety D-154, gave significantly greater seed yield (13·2 mds/acre) than the two exotic varieties, E. C. 4142 and E. C. 4143 ; E. C. 4142 was the better among the two exotics, giving 9 mds./acre of seeds, and it grew to a height of 321 cm. in about 18 weeks from sowing as compared with 293 cm. attained by D-154.

Twenty-two cultures of *Vicia* and 48 of *Medicago* were studied taxonomically and also in respect of desirable characters, such as earliness, disease resistance and capacity to cover soil surface. The monotypic section, *Ervilia*, of the genus *Vicia* could be easily identified by means of its wedge-shaped seeds and continuously hairy style. In *Medicago*, the shape and size of pod appeared to be an important classificatory character ; the relationship between the size of the wing and the keel also appeared to be important. At Delhi, *Medicago hispida* var. *Sardosa* from Australia showed the best growth and coverage ; it was followed by *M. tribuloides* Desr. and *M. truncatula* Gaertn. *Vicia narbonensis* L. showed good growth and coverage and was remarkably free from aphis attack.

Botanical Substation, Pusa.

This substation in Bihar is an important auxilliary station of the Division. The main items of work undertaken include : (1) maintenance of valuable crop collections both indigenous and exotic, and trials of the suitable among them for performance under the North Bihar conditions, (2) breeding and selection work on crops like wheat, linseed, pigeon pea, etc., to obtain strains suitable for the north-eastern tracts of the country, (3) multiplication for foundation stocks of N. P. varieties of crop plants for distribution to growers in that region. The other Divisions of the Institute also conducted their experiments under the conditions of soil and climate obtaining in that tract.

The substation constitutes an important wheat breeding centre under the Coordinated Wheat Rust Control Scheme. In a major trial of the N. P. wheat varieties of the 700-series, N. P. 721 and 745 significantly outyielded the local variety; their increases in yield over N. P. 52 were, however, not statistically significant. In a trial of some of the newer strains belonging to the 700-series, N.P. 799 and N. P. 798 proved most superior; in comparison with these varieties, the Bihar variety-B.R. 319, was poor in yield and susceptible to rusts.

In the trial of wilt-resistant pigeon peas (*Cajanus cajan*), the strain-D-419-2-4 was the best yielder and highly wilt-resistant. The jute strain, D-154, did much better than the exotic varieties, E. C. 4142 and E. C. 4143, as regards branching and seed yield. In chillies, the pungent strains, N. P. Hybs. 17-1-1, 5-1-5 and 7-1-7 gave about 38, 47 and 43 per cent more yield, respectively, than the local variety; the non pungent variety, E. 819, gave 182 per cent higher yield than the local. The tomato variety, Desi Dickson, gave about 877 mds. per acre of fruits and was thus the most outstanding among those, including the American variety-Sioux, under trial. The sweet potato variety, P.A. 17, also gave by far the best yield of tubers.

The crops in connection with the Permanent Manurial and Rotational Experiment and the New Manurial Experiment, being conducted jointly by the Divisions of Agronomy and Chemistry, were grown. In collaboration with the Division of Chemistry, experiments were conducted on the suitability of decalcium phosphate as a phosphatic fertiliser of wheat and on the use of Chilean nitrate as a substitute for ammonium sulphate in the manuring of paddy.

In an experiment on the effect of micronutrients on the yield of paddy, conducted in cooperation with the Division of Agronomy, the results indicated that the treatments incorporating copper salts gave the highest yields which were followed by those obtained from the addition of sulphates of manganese and zinc.

The Entomological Section conducted a survey of insect pests on a number of crops grown at the Substation.

PROGRAMME OF WORK FOR 1953-54.

1. Improvement of wheat with special reference to resistance to rusts and higher yields.
2. Trials of recently-evolved improved varieties of crop plants, such as wheat, linseed, pigeon pea, tomato, sesamum, etc., in the different States of India.
3. Investigations on the utilisation of hybrid vigour in maize.
4. Breeding of some pasture grasses and legumes.
5. Induction and study of polyploidy in crops, like *Brassica*, linseed and sesamum, as a method of crop improvement and trials of some of these polyploids.
6. The study of wild relatives of crop plants and their utilisation in breedings superior crop varieties.
7. Improvement and application of cytological technique.
8. Cytogenetical studies of *Triticum* species and species hybrids and also of their hybrids with related genera.

. Studies on x-irradiation of crop plants, like *Brassica*, linseed and sesame, to evaluate the possibilities of this method in crop improvement.

10. Studies on drought resistance in wheat.

11. Physiological analysis of factors concerned with yield.

12. Plant hormones : Investigations on the role of different hormones on the growth and development of wheat and their usefulness in controlling weeds of cultivated fields.

13. Influence of light and temperature on development and growth.

14. Physiological aspects of plant nutrition : studies on the relation between varietal differences and the uptake of nutrients.

15. Lodging in wheat : Investigations on factors concerned with lodging.

16. Systematic classification of varieties of some crop plants.

17. Study of weeds and of their succession in crop fields.

18. Plant introduction and collection of indigenous plants ; their maintenance and study from the point of view of their possible utilisation.

19. Trials of crop collections, like those of foreign hybrid maize, varieties of sweet potato, etc., at Delhi and in the different States.

REPORT OF THE DIVISION OF SOIL SCIENCE AND AGRICULTURAL CHEMISTRY FOR THE YEAR 1952-53

(Dr. S. P. Raychaudhuri)

SOIL CHEMISTRY

(*a*) Agricultural Chemistry

1. *Fertilizer value of dicalcium phosphate.*—Pot culture experiments conducted in 1951-52 had shown the fertilizer value of both dicalcium phosphate and superphosphate to be similar. During this year field experiments were conducted at Delhi and at the Botanical Sub-station, Pusa (Bihar) for comparing the effect of dicalcium phosphate with that of super-phosphate and bonemeal at equivalent phosphate levels, with and without nitrogen. In Delhi experiment, paddy was directly manured and a residual crop of berseem was grown. At Pusa the treatments were applied direct to wheat (NP 710).

In its direct effect on paddy at Delhi, dicalcium phosphate proved to be as good as super but as regards the residual effect on berseem, the latter gave better results. Both dicalcium phosphate and super were significantly better than bonemeal, singly or in combination with nitrogen.

Similar results were also obtained in Pusa Soil.

2. *Utilization of wild legumes for green manuring.*—In continuation of investigations reported last year, 50 species of wild legumes were analysed for their chemical composition. In the majority of cases nitrogen percentage exceeded 2 per cent and in some cases it was 3·2-5·9 per cent. Laboratory nitrification studies with 18 species showed that the leaves of these legumes nitrified easily and nitrogen was made available for the crop in about 2-4 weeks.

The manurial value of a wild legume incorporated after growing a general crop of *Jowar* as compared to sannhemp grown and buried *in situ* was studied. A treatment of non-leguminous leaves was also included for comparison. In all the treatments green matter was added at 125 lbs. N per acre. All the treatments gave significantly higher yields over no manure. The wild legume *Tephrosia* and the non-legume *Calatropis* proved to be better than sannhemp in their green manuring value.

The seeds of wild legumes analysed were found to contain 3-6 per cent of N. Pot experiment with wheat gave encouraging results as regards their manurial value.

3. *Effect of free phosphoric acid and moisture in superphosphate on its physcial condition and rotting of bags.*—Free phosphoric acid upto 5 per cent had very little rotting effect on jute bags in about 3 months time. Between 5-8 per cent the damage was perceptible and beyond 8 per cent of free acid, the damage was severe. The increase in moisture content from 3·6 to 15 per cent raised the free acid content from 2·7 to 4·5 per cent.

4. *Effect of soaking of seeds and seedlings in nutrient solutions on crop yield.*—Pot experiments were conducted with wheat after soaking the seeds in 0·5 molar solution of ammonium sulphate, ammonium nitrate and super-phosphate. No beneficial effects were observed.

Trials in pots were conducted by dipping the paddy seedlings in (i) FYM and ash, (ii) soil and 5 per cent ammonium sulphate solution, (iii) soil and 2 per cent ammonium phosphate solution and (iv) soil and urine. The paddy yields in individual pots showed good deal of variation due to the fact that the amount of nutrient emulsions sticking to the roots could not be effectively controlled. The average yield, however, indicates the beneficial effect of the treatments.

5. *Effect of synthetic soil conditioner on soil structure.*—Laboratory experiments with three synthetic soil conditioners, Krilium, Poly-Ack and Aerotil, for improving the soil structure of highly clayey soils, were undertaken.

It was observed that treatment of Krilium and other soil conditioners on a black soil with high clay content, produced bigger sized water stable aggregates than the untreated soil.

Results of mechanical analysis without dispersion showed that the synthetic soil conditioners had some beneficial effect on clayey soils by flocculating fine silt and clay particles and Krilium appeared to be the best.

(*b*) Soil Chemistry

6. *Development of rapid soil tests for determining the fertilizer requirements of soils.*—26 soil samples representing different areas of India were analysed by both the standard and rapid methods and the results so far obtained indicated the following : (i) the Morgan's method of estimating the pH of the soil compared well with the standard Hellige's comparator method, (ii) there was no correlation between the available P_2O_5 as estimated by Spurway's rapid method, citric soluble phosphates and 1 per cent potassium carbonate method and the total HCl soluble phosphate, (iii) the brucine method of estimating nitrate was found to be suitable for rapid estimation of nitrate as compared to diphenylamine method.

7. *Studies on the nature and formation of concretion in Indian Soil.*—The nature of concretions from Pusa (Bihar), I.A.R.I. farm, Nagpur and Aligarh were studied. The concretions from Pusa, Aligarh and I. A. R. I. farm were found to be of calcium carbonate with calcium oxide content of 32·9 per cent, 28·1 per cent and 14·3 per cent respectively. The Nagpur concretions were found to be of iron in sandstone, the iron oxide content being 18 per cent while Al_2O_3 in the same was 12·8 per cent.

8. *Base exchange properties of Indian soils in relation to their mineralogical composition.*—The chemical composition of the clay fractions isolated from different soils showed wide variations in SiO_2/Al_2O_3 and $SiO_2/Al_2O_3+Fe_2O_3$ ratios. A large variation in these ratios was found to be accompanied by a similar wide variation in base binding capacity but there was no linear variation between the two. Buffer curves of the clay fractions and some specimens of clay minerals showed that specific clay minerals impressed their characteristic base exchange and buffer properties on hydrogen clays from soils in which they form the dominant constituent. The buffer curves may be used for getting information on the mineralogical nature of the clay present.

9. *Studies on potassium fixation in Indian soils.*—Various factors, such as clay content, moisture status, predominant clay minerals, pH of the medium, base exchange capacity influence the fixation of potash in soils and clays. Soils with higher clay content and higher base exchange capacity fix higher amount of potassium. Bentonite fixes higher amount of potassium than either illite or kaolinite.

10. *Studies on soil organic matter of Indian soils.*—The soils representing different areas of India are being examined for their humus content.

11. *Work at the Botanical Sub-station, Pusa (Bihar).*—(i) *Lysimeter (drainage studies).*—In accordance with the earlier observations it was seen that (A) percolation is proportional to precipitation and (B) loss of plant nutrients (nitrogen, potash and lime) is minimised when the land is cropped instead of keeping it fallow.

It has also been found by following the cropping system reported last year that the removal of a heavy crop of sannhemp, in spite of its being a legume, had an adverse effect on the following wheat crop.

(ii) *Small field pot experiments.*—Manurial-*cum*-rotational experiments were started in 1951 in 9 small field plots (1/1000 acre each). The yield of wheat is somewhat more when it followed either a phosphate manured sannhemp used as green manure or a phosphate treated berseem with a fallow in between.

(c) Soil Fertility

12. *Building up of soil fertility by phosphatic fertilization of legumes.*—In confirmation of the earlier findings, cowpea does not seem to respond to the application of phosphate as markedly as berseem, and the yield of wheat grain obtained in berseem rotation is about 60 per cent higher than after cereal rotation, even with application of fertilizers.

13. *Improvement of composting methods—influence of phosphate addition.*—400 lb. lots of mixed refuse containing cow-dung, litter and urine, were fermented in pots with and without the addition of super-phosphate. Both the original refuse as well as the fermentation products were analysed for the total quantity of organic and inorganic phosphorus content. No appreciable quantity of added inorganic phosphorus is converted into organic phosphorus during the fermentation.

14. *Cow-dung gas plant scheme.*—Laboratory experiments have shown that production of combustible gas from cow-dung proceeded in two stages—an initial stage of rapid and vigorous gas production at a rate of 20 to 25 ml. gas per day per gram of solids, which continued for 10 to 15 days, after which the rate rapidly came down to 3 to 5 ml. gas per gram of solids and continued at this level for more than a month.

It was also found that during the process of digestion of cow-dung, an appreciable fraction of the nitrogen, ranging from 15-20 per cent, was converted into the ammoniacal form. This valuable nitrogen fraction was readily lost when the digested slurry was dried in the sun.

A large cow-dung gas plant has been erected. An Engine Room for housing the sludge pump and Gas Engine has also been constructed.

(d) Micronutrient

15. *Trace elements in some Indian grasses, forage crops, etc.*—Nine samples of phosphatic fertilizers were analysed for Mn, Co and Cu. The content of cobalt in

all the fertilizers with the exception of rock phosphate varied from 1·25 to 5·75 p.p.m. and copper from 21·0 to 36·0 p.p.m. Rock phosphate contained a much higher amount of cobalt and copper. Bone meal showed a much lower content of Copper. The cobalt and copper content of the quantity of fertilizers applied were too insignificant as judged from their P_2O_5 content to help their appreciable increase in the soil.

16. *Uptake of micronutrient elements by grasses and forage crops under different fertilizer treatments.*—(i) *Pot Culture experiments with Sudan grass in Delhi and Pusa soils.*—Experiments were conducted with Delhi and Pusa soil for studying the uptake of micronutrients by Sudan grass under different fertilizer treatments. In Delhi soil Muriate of potash and lime were found to enhance the uptake of manganese, cobalt and copper being uneffected by different treatments. In Pusa soil, however, muriate of potash enhanced the uptake of cobalt and copper. Ammonium sulphate and sulphur depressed the manganese uptake, whereas, super enhanced its uptake.

(ii) *Pot culture experiments with Phalaris Minor in Delhi and Pusa soils.*—Super and lime seem to enhance the uptake of cobalt by this grass in Delhi soil. Ammonium sulphate and super enhanced the uptake of copper whereas lime depressed it. Lime, on the other hand, enhanced the uptake of Mn. In Pusa soil, the uptake of Co was almost uniform under different treatments, although the quantity was much less than in Delhi soil. Sulphur, Ammonium sulphate and Super enhanced the uptake of Copper.

(iii) *Micronutrient status of different cuttings of berseem.*—Co and Cu tend to decrease from the 1st to the 2nd cutting and then increase steadily to the 4th cutting. Mn, however, showed a steady increase from cutting to cutting except in the 4th one where it records a drop.

II. Soil Physics

17. *A comparative study of the behaviour of sandy and loamy soils of the I. A. R. I. farm under different treatments.*—The sandy and loamy soils of I. A. R. I. farm were treated with different doses of lime, green manure (guar), farm yard manure at different stages of decomposition and their effect was observed on the growth of oats in pots.

Yields of both oat seed and straw have shown that green manure treatment manifested maximum increase in comparison to other treatments including control. Loamy soil responded better than sandy soil.

50 per cent to 75 per cent higher yields were obtained by green manuring followed by F.Y.M. and lime gave 25 per cent and 10 per cent increases respectively over control. Light soil was better benefited by lime.

18. *Efficiency of various indigenous ploughs from different States.*—Ploughing was done with the following ploughs : Ujain, Saagur, Muzafarpur, Ranchi, Patna, Hyderabad and Bailary. The last named plough was found to be the most efficient in pulverising the soil and breaking the largest number of clods and turning into the soil crumbs and exposing it better for irrigation and aeration.

19. *Permeability co-efficient of different sizes of soil aggregates.*—It has been found that aggregates of 1·0 mm. to 3·5 mm. size exhibit greatest drainage capacity and permeability and allowed largest amount of water to pass through the pore-space than other sized aggregates.

III. Physical Chemistry

20. *Studies on the clay fractions of red and laterite soils of Bihar.*—Thermal dehydration curves of the clay fractions from the 1st and the 5th horizons of the red and laterite soils from Hazaribagh and Kanke (Bihar) were found to resemble those of pure kaolinite, the inflexion temperatures being slightly low. The electroviscous curves were also found to be almost straight lines characteristic of kaolin. The electrometric titration curves were, however, found to contain only one inflexion point, while two were to be expected if it were kaolin. Similarly the fixed K_2O content of these hydrogen clays were too high ranging from 2·83 to 3·50 per cent in different horizons. These discrepancies between the different methods were attributed to the large amount of free Fe_2O_3 which these laterite soils contained. The high value of potash might have resulted from the clay having been derived originally from rock minerals rich in potash.

21. *Physico-chemical studies on soil humus and its interaction with clay minerals.*—The electrometric titration curves obtained by titrating mixtures of a clay mineral (H-kaolinite or H-montmorillonite or H-illite) with each of the three humus fractions obtained from the *Kari* soil of Travancore prepared by the method of Tyulin were compared with those of the additive curves obtained by summation of such curves for individuals composing the mixture singly. It was found that below pH 7·0, a mixture of H-kaolin and the third fraction of humus had a considerably lower base absorption capacity than the sum-total for the individuals under the same conditions. This indicated the formation of complexes between these two, locking up some of the exchangeable sites of the individuals. On the other hand, mixtures of H-illite and the 1st humus fraction had a significantly higher base absorption capacity than that indicated by the sum for the individuals. This can be attributed to hydrolysis of the Oxygen bridge in this humus fraction by H-illite resulting in the release of perhaps more OH-groups capable of absorbing bases.

22. *Studies on ionic exchange equilibrium in clay and clay minerals with special reference to alkaline soils.*—From certain preliminary field observations, the development of alkaline patches in Pusa Botanical Sub-station (Bihar) is attributed to the movement of ground water from neighbouring areas. Steps suggested for its control or check are lowering of ground water level or replenishing water at suitable places in nearby ponds and wells. In addition to these movements temperature may be another factor influencing the equilibrium between Ca and Na which is closely related to the development of alkalinity in soils. A new equation has been proposed to study the equilibrium between Ca and Na as this appears to apply better than the equations proposed by earlier workers for the equilibrium between K and Ca with bentonite solutions. Vanslow's equation was found to fit second best.

IV. Soil Survey

23. *Intensive cultivation scheme in Delhi Villages.*—(i) A detailed soil survey of nearly 5,500 acres in certain Delhi villages was completed. Soil maps and maps showing the land classes were prepared. A large number of surface and subsurface soil samples, profiles from normal soil areas and alkaline tracts have been analysed. The alkaline soils show a high moisture equivalent. The soils are of an open texture and usually clay accumulates in the B-horizon. The soils come under the world group of grey and brown soils of desert and semi-desert regions.

(ii) *Development of salinity and alkalinity.*—The soils are normally well drained, but when well water is used for irrigation or in areas of low topography saline and alkaline soils have developed. In low lying areas the soils are alkaline and usually concretionary lime occurs within a short depth from the surface.

(iii) *Qumaruddin Nagar.*—A plan for soil erosion and water conservation was prepared and bunds at suitable places for soil and water conservation measures have been made.

24. *Soils of Rann of Cutch.*—Samples of laterite and associated white clays were analysed. Laterite contained 28·0 per cent iron oxide, 20 per cent kaolin, and the rest as quartz and other elements. The white clay contained 62·0 per cent kaolin, 2·0 per cent iron oxide and quartz making up the rest. The cation exchange capacity of clay was 6·0 m.e. confirming the kaolinitic nature of the clay. The laterite was evidently developed under a high and fluctuating water table.

The heavy minerals, eliminating iron oxide and rare oxides in the fine sands, were grouped into resistant, non-resistant and micas, and plotted in triangular diagrams indicated the differences in the sources of the sediments and also the nature of the sediments.

A new type of sulphate reducing organism was found in the Cutch soils. Preliminary work has shown that the liberation of iron in the soil is at least partly due to the activity of these organisms.

25. *Chambal-Hydel Project, Rajasthan.—Study on the black soils of Kotah.*—Four of the black soil profiles were studied. The soluble salt content has been found to vary with different places. The nitrogen content varies from 0·03 to 0·06 per cent in the top two layers of the profile. The clays of the above soils were separated and their SiO_2/Al_2O_3 and base exchange property were found out which show that these clays are montmorillonite in nature, even the soil as such has a base exchange capacity varying from 30 to 43 m.e. per cent.

V. ORGANIC CHEMISTRY

26. *Oils, fats and oilseeds.*—(*a*) *Detection of adulteration of ghee.*—(i) A procedure has been developed whereby adulteration of ghee, when adulterated with 5 per cent of hydrogenated oil containing only 0·005 per cent of tyrosine ethyl ester as latent indicator can be readily detected. The method depends primarily on the use of diazotised 4-amino-diphenyl as reagent. It has also been shown that tyrosine ethyl ester cannot be readily removed from oil solutions by warm dilute acids or alkalies or by treatment with adsorbing agents. This is an advantage which is not probably shared by other indicators suggested so far.

(ii) Spectrographic examination of several specimens of cow's and buffalo's ghee, several hydrogenated oils from different factories as well as crude groundnut and sesame oils showed that they do not have absorption bands at 228, 260 and 310 mμ. This indicated that derivatives of di-and tri-ethanoid conjugated fatty acids may possibly be successfully used as latent indicators for the detection of adulteration of ghee. These conjugated acids can be easily and cheaply prepared by isomerisation of fatty acids from ordinary vegetable oils and cannot be selectively removed from the hydrogenated oil by any known procedure.

(*b*) *Determination of quality of oil in small samples of oil seeds.*—The method of determining yield and iodine value of oil in small samples of oil seeds reported last year has been applied to a further number of different seeds. In all cases it was found that the yields of extractives using carbon tetrachloride was the same as with benzene and that iodine value of oil determined by present procedure was same as that of expressed oil using conventional procedure. Study of bromine vapour method of determining iodine value showed the method to be too unreliable to be used in the present connection.

27. *Insecticides and fungicides.*—(*i*) *Extraction of nicotine from tobacco.*—It was found that countercurrent extraction of powdered tobacco waste, previously impregnated with ammonia and water, with kerosine in a battery of 4 extractors gave almost complete extraction of the nicotine in the tobacco. The nicotine could be removed from the nicotine bearing kerosine in a continuous process by passing this in finely divided condition over a bed of dilute sulphuric acid. 42 per cent nicotine sulphate has been prepared by this procedure. The calorific value of the spent tobacco waste after removal of the nicotine is about 4,600 B.T.U. and compares well with that of bagasse. If sulphuric acid of strength below about 20 per cent is used there is a tendency for emulsification.

(ii) *Organic thiocyanates.*—Detailed study of the reaction between longifolene and acetic acid and longifolene and monochloroacetic acid showed that about 25 per cent of the longifolene can be converted to longifolyl mono-chloracetate or longifolyl alcohol, two chemicals for which commercial use can possibly be developed. The balance of 75 per cent is converted to a stabilised hydrocarbon, which does not discolour or leave resinous residue on keeping for a long time. This indicates that the longifolene fraction of Indian terpentine oil, which is at present a waste product, may be profitably used.

(iii) *Chlorinated Terpense.*—Specimens of pinene fraction, carene fraction, longifolene, Indian terpentine oil, adduct of trichloro-ethylene with carenes and isomerised carenes and adduct of longifolene with carbon tetra-chloride, mono-chloroacetic acid, and trichloracetic acid have been chlorinated first at 0° and then at 100°C till no further absorption of chlorine took place and the products have been assayed for insecticidal activity against *Tribolium castaneum* by the Entomology Division. Only products obtained from carenes and containing above about 45 per cent of chlorine show any appreciable activity ; other chlorinated products of the same chlorine content showed activity of a lesser order.

28. *Animal products.*—It has been shown that hydrochloric acid can be successfully substituted for sulphuric acid in the preparation of dicalcium phosphate and bone manure from bones. This may prove to be of economic importance in India, since India is not a sulphur producing country, but hydrochloric acid may be produced here at a cheap rate from electrolytic chlorine. The bone residue, thus prepared, is a good nitrogenous and phosphatic manure and has a composition of N—8 per cent ; P_2O_5—20 per cent ; citric acid soluble P_2O_5—11 per cent.

VI. SOIL MICROBIOLOGY

29. *Acceleration of the fermentation of the green manure, sannhemp in Delhi soil.*—Treatment of sannhemp with dilute cow-dung emulsion (5 per cent) in water

before incorporating in soil accelerated fermentation as judged by laboratory and pot culture experiments. Soil which received treated sannhemp produced 12 per cent more CO_2 in 16 days as compared to 3 per cent produced by treatment with sterilized emulsion. In pot culture experiments the yield of wheat was increased by 40 per cent over the control against 31 per cent increase by treatment with sterilised emulsions.

30. *Activation Azotobacter.*—Inoculation with activated strain of *azotobacter* in the presence of different energy supplying materials increased the yield of *Marua* (Ragi). In the presence of berseem hay the yield was increased by 57 per cent over the hay treatment alone. With F. Y. M. the increase was 50 per cent. With wheat straw there was no gain over the control but the depressing effect of straw was reduced to some extent.

31. *Effect of different phosphates on the fixation of nitrogen through legumes (Guar) and its subsequent effect on wheat.*—It was found that while pea and sannhemp could make use of different phosphates like super, bonemeal, Tr. nodule and Singhbhum phosphate in varying degrees, Guar could use only super.

32. *Mechanism of nitrogen fixation in rohar.*—It has been found that in the case of rohar mechanism of nitrogen fixation is not like that of other legumes. But it is to some extent by the plant itself. With NP51 it was found that the crops required nearly 300 lb. of N per acre out of which nearly 100 lb. is returned to the soil in the form of shed leaves and floral parts. To utilize this nitrogen it is suggested that field should be ploughed immediately after the harvest of the crop.

33. *Inoculation of legumes.*—Experiments with grain conducted at a number of different stations showed that normal method of seed inoculation is not very satisfactory. Inoculation of soil with soil culture or with soil from the field in which grain grew well in previous years proved better than the seed inoculation. Similar is the case with Guar.

34. *Modified method of using sannhemp for manurial purposes.*—The method consists in allowing the crop of sannhemp to mature and then to harvest for seed, fibre and straw. The seeds are to be added to the soil for manuring. By this method 8·8 md. of fibre, 68 md. of straw and 36 md. of onions were obtained over the method normally followed.

VII. BIOCHEMISTRY

35. *Chemical composition and nutritive value of wheat.*—(*a*) *Chemical composition of Indian wheat.*—Thirty varieties of Indian wheat have been analysed for their content of nitrogen, moisture, ether-extract, crude fibre, ash, insoluble ash, calcium, phosphorus and gluten. The varieties have been found to differ markedly in some of the constituents analysed. Their nitrogen and phosphorus content varied from 1·9 per cent to 2·05 per cent and 0·26 per cent to 0·41 per cent respectively.

(*b*) *Riboflavin and thiamine content of Indian wheat.*—24 varieties of Indian wheat have been analysed for their content of riboflavin (vitamin B_2) which has been found to vary from 0·92 to 1·09 µg per gram.

A microbiological method for the estimation of thiamine (vitamin B_1) has been developed. The bacterial response was measured both by turbidity and by titration. The former method appears to be more satisfactory. A few varieties of wheat

were analysed for their content of thiamine which varied from 4·6 to 6·6 μg per gram.

(*c*) *Nicotinic acid content of Indian wheat.*—Nicotinic acid has been found to vary markedly in different varieties of Indian wheat. It was, therefore, thought to be of interest to study the influence of soil and climatic factors on this vitamin. Samples of the same variety of wheat grown in different parts of India were, therefore, analysed and found to vary in their content of nicotinic acid which ranges from 35·0 to 64·1 μg per gram.

36. *Nature of protein in food and feeding stuff*—(*a*) *Paper partition chromatography.*—The technique of paper chromatography developed in this laboratory was followed for the analysis of amino acids in a few samples of wheat, gluten and mango seed kernel. The amino acids identified in wheat and gluten are : Cystine, aspartic acid, glutamic acid, glycine, threonine, alanine, tyrosine, histidine, arginine, lysine, proline, valine (and methionine), leucine, tryptophane, and phenylalanine. Mango seed kernel was found to contain, in lesser quantity, all these amino acids except tryptophane which has not been estimated. Mango seed kernel, on the other hand, appeared to contain an additional amino acid, probably γ-aminobutyric acid.

(*b*) *Microbiological method.*—Methionine, a sulphur containing essential amino acid, has long been known to play an important role in nutrition. A microbiological method has been developed for its estimation in plant materials. Three organisms, such as *Leuconostoc mesenteroide, streptococcus faecalis* and *Lactobacillus arabinosus* were used for the estimation of methionine in order to compare their efficiency and *Leuconostoc mesenteroide* appears to be more reliable and satisfactory. The varieties of Indian wheat analysed were found to contain 0·19 per cent to 0·40 per cent of methionine.

37. *Amino acid composition of a few typical Indian soils.*—A preliminary survey of important soil groups of India with reference to the content and distribution of amino acids in them was undertaken. Surface soil of six typical Indian soils were analysed for their amino acids by the method of paper chromatography. The amino acids identified in these soils are : alanine, arginine, aspartic acid, glutamic acid, glycine, histidine, leucines, phenylalanine, proline, serine, threonine, tyrosine and valine. No marked difference was observed in the amino acid make up of the soils though indications of their variation in quantity are present.

38. *Utilisation of mango seed kernel.*—Preparation of starch from mango seed kernel was continued. An improved method was found out by the introduction of chlorine in place of permanganate and sulphur dioxide. By this method white starch was prepared more economically. The viscosity of chlorine-treated starch and unbleached starch compared well with that of corn starch.

39. *Chemical composition and nutritive value of pulses.*—Seven varieties of pulses have been analysed for their content of moisture, protein, ether extract, crude fibre, ash, insoluble ash, soluble minerals, calcium and phosphorus. Their protein content has been found to vary from 8·4 to 11·9 per cent.

The Biological value of protein in ten varieties of pulses has also been determined by the growth method. The Biological value varies from 0·24 to 1·61.

40. *Biochemical studies on tomato.*—37 varieties of tomato hybrids were analysed

for their vitamin C content which varied from 23·6 to 60·5 mg. per 100 gm. The ripe fruits contained the highest amount of this vitamin.

VIII. PHYSICS

41. *Quantitative estimation of trace elements by Cathode layer arc technique.*—A project was undertaken last year to determine the optimum segment of the cathode layer which when focussed under the experimental conditions, would illuminate the slit uniformly without much sacrifice of the intensity. It was observed that for most of the spectral lines the light from the segment starting 1 mm. away from the cathode satisfied the conditions under the experimental set up. This year a fourth segment was also included, so as to understand the trend of the change in the intensity distribution beyond the cathode enrichment layer as well.

Except for Co line, the ratio of intensities of the lines studied is near about unity in the 3rd segment.

To understand how the arcing material and dimensions of the cathode affect the intensity distribution it was decided to study the problem in greater detail by taking (1) different dimensions of the cathode, (2) different types of arcing materials, e.g. carbon powder alone, carbon powder and silica and finally carbon powder and soil base and trace element mixture. Spectral lines emitted from the second segment are uniform when carbon powder alone is arced. This uniformity partly shifts to the third segment when quartz is introduced and more or less completely shifts to the third segment when conducting material is introduced in the arc. Decrease in the size of the cavity enhances the cathode layer effect considerably being a function of temperature. Consequently, though the weight of material arced in the cathode cavity was about $\frac{1}{3}$rd of the weight filling the larger one, the intensity of the lines emitted did not show a proportionate reduction.

42. *Direct current arc technique using copper electrode.*—Two types of cathode, namely, (*a*) flat, (*b*) cored were used. Arcing the material in the cored cathodes was found to be more suitable for the detection of Zn plus B than arcing the material by pasting it on the flat end of the cathode. On the other hand, the latter method was more sensitive in the case of Mn, Fe, and Bi as shown by the number of steps in which the spectral lines of those elements are present.

43. *Nicotine in Tobacco.*—(*a*) *Grafting experiments.*—In order to study the movement and synthesis of the alkaloid in plants it is proposed to estimate the nicotine content in the shoots of tomato plants grafted on the tobacco plants. The quantities involved are very small and the present apparatus will have to be modified for the purpose.

(*b*) *Nicotine in sample collections.*—Nicotine was estimated in 34 collections of tobacco in Botany Division by absorption spectrographic technique. The percentage of nicotine ranges from 0·56 to 4·02.

IX. METEOROLOGY

54. *The growth of wheat as influenced by the date of sowing and the micro-climate.*—With a view to understanding the influence of micro-climate on the growth and yield of wheat several agronomical characteristics and meteorological factors were recorded at regular intervals in wheat crop. The data are being analysed.

PROGRAMME OF WORK FOR 1953-54

Section I.—Soil Chemistry

(a) *Agricultural Chemistry*

1. Fertilizer value of dicalcium phosphate.
2. Soaking of paddy seedlings in nutrient solutions.
3. Effect of synthetic soil conditioners on soil structure.
4. Fertilizer value of ammonium chloride and ammonium sulphate-nitrate (jointly with Agronomy Division).
5. Fertilizer value of finely ground rock phosphate from Singbhum and Trichinopoly (jointly with Agronomy Division).
6. Pot culture experiments with Hyperphosphate in acid soils from Ranchi and Travancore.
7. Pot culture experiments with mixed N. P. fertilizers received from National Chemical Laboratory, Poona.
8. Experiments with Homoeopathic drugs sent by Shri Valabhdas through the Hon'ble Prime Minister.
9. Preliminary pot experiments with 'soil sulphaid' (a Trade Product), on an alkaline soil from Delhi village.

(b) *Soil Chemistry*

1. Development of rapid soil tests for determining the manurial needs.
2. Studies on the nature of the concretions in Indian soils.
3. Studies on alkaline soils of India.
4. Studies on the typical profiles of paddy soils of India.
5. Potassium fixation in Indian soils.

(c) *Soil Fertility*

1. Building up of soil fertility by the phosphate fertilization of legumes.
2. Effect of different systems of crop rotation on the soil.
3. Compost experiments.
4. Production of fuel gas and manure for cowdung and litter.

(d) *Micro-nutrients*

1. Micro-elements in grasses forages, etc.
2. Micro-nutrient status of Indian soils.
3. Die back in citrus (ICAR Scheme).

Section II.—Soil Physics

1. Studies on soil moisture and soil structure.

Section III.—Physical Chemistry

1. Studies on Ionic exchange equilibrium in clays and clay minerals.
2. Studies on electro-osmotic properties of clay salts and precipitates.
3. Studies on electro-kinetic properties of clays from a normal and alkaline Delhi soil patches and of pure clay minerals.
4. Relative contribution of clay minerals, free silica and sesquioxides to cation exchange capacity and water holding capacity of Indian soils.
5. Studies on anion exchange capacity of Indian soils.

Section IV.—Soil Survey

1. Intensive cultivation scheme (Delhi villages).
2. Soils of Rann of Cutch.
3. Soils of Chambal Hydel Project (Rajasthan).
4. Reclamation work at IARI.

Section V.—Organic Chemistry

1. *Oils, fats and oil seeds—*
   (*a*) Detection of adulteration of ghee.
   (*b*) Development of methods for determining quality of oil in small samples of oil seeds.
   (*c*) Prevention of rancidity of oils and fats.

2. *Pesticides—*
   (*a*) Development of Semi-commercial method for the production of nicotine sulphate from tobacco waste.
   (*b*) Synthesis of organic thiocyanate from indigenous bases.
   (*c*) DDT Scheme of ICAR.

Section VI.—Soil Microbiology

1. Utilization of indigenous phosphates for the fixation of atmospheric nitrogen through leguminous plants.
2. Study of the mechanism of nitrogen fixation through Rahar.
3. Inoculation experiments with *rabi* legumes.
4. Acceleration of the fermentation of green manures.
5. Use of modified method of manuring with sannhemp for wheat.
6. Activation of *Azotobacter*.
7. Study of wild leguminous plants for the fixation of atmospheric nitrogen.
8. Production of fuel gas from cowdung.
9. Study of nitrogen fixing flora of tank silts.
10. Effect of micro-organism added along with F.Y.M. on the yield of wheat.

Section VII.—Biochemistry

1. *Studies on soil metabolism—*
   (*a*) Paper chromatographic estimation of sugar and amino-acids in soil.
   (*b*) Soil enzymes.
2. *Nutritive value of food, feeds and fodders—*
   (*a*) Amino-acid composition.
   (*b*) Biological value.
   (*c*) Chemical composition & Vitamin content.
3. Chemical composition and nutritive value of Indian wheat (ICAR Scheme).

Section VIII.—Physics

1. Comparison of the spectrogaphic-colorimetric and chemical methods of estimation of major and minor elements.
2. Development of a method for the estimation of nicotine present in small quantities in tobacco-tomato grafts.
3. Longitudinal and transverse distribution of intensity near the cathode layer in carbon arc.

REPORT OF THE DIVISION OF ENTOMOLOGY FOR THE YEAR 1952-53

(Dr. E. S. Narayanan)

SECTION OF PARASITOLOGY

A. Fundamental Studies

1. *Bionomics and skeleto-muscular mechanisms of Lestodryinus pyrillae Kieff. (Dryinidae : Hymenoptera).*—The bionomics of this important nymphal parasite of *Pyrilla* spp. were completed. Studies on the skeleto-muscular mechanism of the head, thoracic legs and prothorax were completed. In the course of studies of the head region, a new type of articulation was observed which hitherto seemed to have escaped the notice of earlier morphologists. The articulation of head with propectus is highly specialised in *Lestodryinus*. In this parasite, the occipital processes are wide apart and oppose the posterior tentorial pits and do not take part in the articulation as observed in some other hymenopterous parasites. In this case, the cervical apodeme which is a mesal expansion in the anterior region of the horizontal apodeme is seen articulating with the occipital condyle present on the rim of the foramen magnum. Thus, a ball and socket type of articulation is formed to facilitate an all-round movement of the head.

2. *Effect of alternate hosts on the sex-ratio of Stenobracon deesae.*—Experiments were conducted to find out whether the alternate laboratory host, *Corcyra cephalonica* would be suitable to breed the parasite, *Stenobracon deesae*. Two females bred from its natural host, *Chilo zonellus* were selected ; one of them was allowed to breed on *Corcyra* and the other on *Chilo*. Breeding was continued on the same host generation after generation and, the longevity, fecundity and sex-ratio of the progeny were recorded. It was observed that the parasites that were bred on *Chilo* were more vigorous and healthy than the parasites that were bred on *Corcyra*. Further, the percentage of females obtained from *Corcyra* steadily decreased with each generation. Further studies are in progress.

3. *Effect of refrigeration of pupae on the pigmentation of the adult Microbracon brevicornis Wesm.—Microbracon* pupae that were kept in the frigidaire for 10 to 75 days, on emergence showed a graded series of dark parasites, *i.e.*, from dark gray to jet black. Experiments showed that low temperature alone was responsible for the development of dark pigmented parasites and factors like light and humidity did not play any role in the production of melanic forms. The production of melanic forms is probably due to the inability of cells to dispose of the breakdown products during metamorphosis under low temperature tending to accumulate as the period of refrigeration is extended.

4. *Superparasitism in Bracon gelechiae Ashmd.*—Superparasitism in the case of *Bracon gelechiae* is mainly influenced by the size of the host that the parasite encounters. The total number of eggs laid by a parasite and the number of host larvae accepted for parasitization are dependent on the size of the host larvae. If the parasite is allowed to parasitize on different instars of host larvae, superparasitism

is seen only in the case of 6th and 7th instars, but not in the 3rd, 4th and 5th instar larvae. As the number of eggs per host increased beyond a maximum of 6, the sex-ratio of the developing progeny was dominated by males. Superparasitism decreased as the host density increased. The longevity of the parasite with food supply was about 31 days and without food about 9 days. The maximum number of eggs laid by a female with food supply was 219 eggs, while the female without food laid only 84 eggs. Three days old parasites laid the maximum number of eggs with an average of 7·92 per day ; 30 and 40 days old ones laid on an average 1·91 and 1·75 eggs per day respectively. A maximum of 10 parasites could develop on a full-fed larva.

5. *Superparasitism in Trichogramma evanescens minutum* R.—When 50 eggs of *Corcyra* were exposed to a single mated female for one hour, about half their number were left unparasitized. When the time of exposure was increased to 2, 4, 8, 16 and 29 hours, no superparasitism was observed. When the number of host-eggs was reduced to 40, 30, 20, 10 and 5, very little of superparasitism was observed. When the time of exposure was increased to 2, 4, 8, 16 and 24 hours and the number of host-eggs were reduced to 10 and 5, high superparasitism was observed. When host eggs were exposed in clusters instead of evenly spreading them, superparasitism was observed. The maximum number that could complete the life-history and emerge from a single host-egg was three. Usually two emerged. It was observed that parasites that emerged from highly superparasitized condition were unable to mate with the healthy ones.

6. *Studies on Indian Ichneumonidae.*—Ichneumonidae is a parasitic family of great economic importance in biological control of insect pests. Sub-family Pimplinae was taken up and a key to the eight tribes under it, *viz.*, Polysphinctini, Theroniini, Pimplini, Acaenitini, Rhyssini, Ephialtini, Xoridini and Poemeniini was prepared. Catalogues of the tribes Polysphinctini, Theroniini and Pimplini under the above sub-family were prepared. Similar studies on Indian Banchinae with key to its three tribes were made, besides a catalogue to its tribe Glyptini.

7. *Parasites of San Jose scale.*—Further investigations on the parasites reared from San Jose scale collected from Kashmir revealed that out of 99 species of Chacidoidea, *Penissopterus narayani* was found to be new.

B. Biological control of insect pests (Mass breeding of parasites)

(1) *Trichogramma evanescens minutum* R.—During the year under report about $3\frac{1}{2}$ million parasites were bred on the eggs of *Corcyra cephalonica*.

(2) *Bracon gelechiae* Ashm.—This parasite of potato tuber moth was also bred in the laboratory in thousands.

(3) *Apanteles* sp. n.—A newly recorded parasite on *Platyedra gossypiella* was bred for the first time under laboratory conditions. A new oviposition cage was also devised for the purpose of breeding the parasite in large numbers.

(4) *Microbracon brevicornis* Wesm.—This parasite was recorded for the first time on pink bollworm and was bred on a mass scale in the laboratory.

(5) *Chelonus* spp. n.—These parasites were recorded on the host. *Heliothis* sp. They were bred on *Corcyra* eggs in the laboratory.

The following parasites were supplied to correspondents :—

(i) About a lakh of parasites were sent to the Entomologist, Agricultural College, Nagpur (Madhya Pradesh).

(ii) 1,500 full-grown *Corcyra* larvae and 3·0 c.c. of eggs were supplied to Mr. G. W. Angalet, Entomologist of the U. S. Dept. of Agriculture for breeding parasites of the pink bollworm of cotton (*Platyedra gossypiella*) for export to U. S. A., for their introduction and establishment in the American cotton belts.

(iii) 24,000 parasites of *Trichogramma* were sent to the Director, Plant Industry, Indore, to release them against *Sesamia* sp., (wheat stem borer) in the field.

(iv) About 200 parasites of *Bracon gelechiae* were supplied to the Entomologist, Cuttack, Orissa.

C. Studies in Insect Physiology

Factors governing the production of winged aphids, *Rhopalosiphum pseudobrassicae* (Davis).—The correlation of water content in the host-plants with the production of winged aphids was studied. Studies conducted so far have indicated that the interaction of humidity and temperature leads to a reduction in the water contents of the parent aphids, thus resulting in the development of wings in the offsprings.

D. Apiculture

A study on the possibility of keeping honey bees (*Apis indica* Fabr.) at I. A. R. I. (Delhi), was continued. From the beginning of June, the activity of the bees and brood rearing slowed down due to hot and dry weather, but increased from about the middle of July, due to rains resulting in good pasture. This activity continued upto the end of October, when there was again a decline due to shortage of pollen and nectar. From the beginning of November to the end of January, the activity was practically at a standstill owing to severe cold. From February onwards the bees again resumed activity and the colonies were in good flourising condition during March, April and May, when plenty of nectar and pollen were available.

The flowers from which the bees collected nectar and pollen in and around I. A.R.I. were recorded.

SECTION OF SYSTEMATIC ENTOMOLOGY

(1) The detailed morphology of *Scelio oviphagus* sp. n. (Serphoidea : Hymenoptera) an egg parasite of *Hieroglyphus nigrorepletus* I. Bol. was worked out.

(2) Little attention was hitherto paid to the study of homology of male genital armature of the two sub-orders, Terebrantia and Tubulifera of Thysanoptera and its significance in the systematic studies of the group. The structure of the genitalia in these sub-orders was found to be remarkably different as also in some of the genera and species examined in each case.

(3) Genitalia of the males of the genera, *Eumenes*, *Alastor*, *Odynerus* and *Rhygchium* (Vespoidea : Eumenidae) consisting of 20 species were studied in detail. A catalogue of Eumenidae of the Oriental Region except keys to the genera was completed.

(4) Two new forms of Reduviids from Delhi, *viz.*, *Rhinocoris lapidicola* sp. n. and *R. nysiphagus* sp. n. predators on *Nysius inconspicuus* Linn., a serious pest of tobacco capsules in India were described in detail.

(5) *Insect morphology :* Studies on the permeability of insect chitin to aqueous stains and their relationship to vulnerability were studied in desert locust, *Schistocerca gregaria* F. The results obtained have shown that in addition to the normal abraised areas in insect cuticle, other natural unabraised areas either with or without the soluble lipoid cement layer also exist. Among the aqueous stains tested, crystal violet was found to be the best fat solvent.

The first tarsal joint of the hind leg of *Pyrilla perpusilla* Walker was found to be the most vulnerable region to react positively to insecticides, like nicotine sulphate and BHC. It was also found in that particular region of the first tarsal joint, where prominent and well differentiated hypodermal layers of the cuticle were present gave a positive reaction to the insecticides.

SECTION OF INSECT ECOLOGY AND TOXICOLOGY

1. *Ecological studies for constructing a Biometer for Trichogramma evanescens minutum R.*—The rearing of this parasite was carried out under five temperatures (12°C, 18°C, 25°C, 30°C and 35°C) and two humidities (35% and 75% R.H.) and observations were recorded on (*a*) number of days required for the parasitised eggs of *Corcyra cephalonica* to blacken, (*b*) the period required for the parasite to emerge, (*c*) the longevity of the parasite, (*d*) the percentage of parasitisation and (*e*) the percentage of emergence under different conditions of temperature and humidity. Complete development did not take place under both the humidities at 12°C and under 35% R.H. at 35°C. The completion of full life-cycle took 17-23 days, 8-16 days, 7-11 days, and 7-10 days at 18°C, 25°C, 30°C, and 35°C respectively.

2. *Studies on Phadka*, (*Hieroglyphus nigrorepletus*).—The biology and bionomics of this pest have been completed. The average nymphal periods have been observed to be 7·4, 7·5, 7·5, 8·0, 9·0, 9·5, 11·1 and 13·3 days respectively for the different instars under laboratory conditions, the average total nymphal periods being 70 and 61·7 days for the females and males respectively. The total life period since hatching worked out to an average of 118·5 days.

3. *Studies on the distribution and sampling of insect pests.*—Precision experiments were carried out on eight species of insect pests *viz.*, *Rhopalosiphum pseudobrassicae.*, *Myzus persicae*, *Pyrilla* sp., *Macropus excavatus*, *Scirpophaga nivella*, *Argyria sticticraspis*, *Emmalocera depressella*, and *Chilo zonellus.*

The optimum shapes and sizes of samples and the optimum percentage of the population to be sampled have been determined. Also a correlation between the yield of jowar grain and the incidence of the jowar pest, *Chilo zonellus* Swin. was worked out to be : X_1 6·6201 X_1 - 0·9257 X_3—27·17 (X_1=yield per plant in gms., X_3=percentage of length infested, X_1=number of ears).

4. *Studies on insect desiccation.* - With *Periplanata americana* adults as material desiccation was found to be least in the case of starving insects and highest in the case of dead ones. The normal water content was determined in 32 insect stages belonging to 19 species and the water content at the time of death due to desiccation

was determined in 14 insect stages belonging to 9 species. Efforts were made to estimate the potentiality of these stages to augment the deplition of water content by converting the solid matter of insect body into metabolic water.

5. *Studies on the effect of the ecological factors*, viz., *temperature on insects toxicological response*, viz., *susceptibility to insecticides*.—The earlier observations on effect of temperatures on insect resistance to DDT dust and to DDT suspension were confirmed using as test insects. *T. castaneum* adults and mosquito (*Culex fatigans*) larvae respectively. The observations in general corroborate the earlier conclusions that insect susceptibility increases with treatment temperature and decreases with post-treatment temperature. The results obtained with mosquito larvae were finally studied, interpreted and prepared for the press.

6. *Persistence of toxicity of modern insecticides under different ecological conditions prevailing in different crops*.—Persistence of 19 different formulations formed from six basic chemicals, *viz.*, DDT, BHC, Chlordane, Aldrin, Parathion and Toxaphene in sugarcane and cotton crops was studied. Persistence of the same insecticide was detected upto different periods in the same crop but using different test insects as detectors. The seasonal effect was also definitely perceptible. Using cloth instead of leaf it was found that sunlight causes some deterioration of DDT. In another set of experiment a 0·25% emulsion of dieldrin remained toxic upto 40 days on maize plants.

7. *Bioassay of insecticides*.—The order of toxicity of different modern insecticides to some Indian insect pests was tentatively determined to be as follows :—

(i) *Oxycarenus laectus* K.—

(*a*) 24 hours after treatment : Parathion>BHC>Aldrin>DDT>Lethane

(*b*) 48 hours after treatment : Parathion>BHC>Aldrin=DDT>Lethane

(ii) *Rhopalosiphum pseudobbrassicae* (Davis)—

(*a*) 24 hours after treatment : Parathion> BHC>DDT>Chlordane> Lethane

(*b*) 48 hours after treatment : Parathion>BHC>DDT>Aldrin>Chlordane>Lethane

(*c*) 72 hours after treatment : Parathion>BHC>Aldrin>DDT>Chlordane>Lethane

(iii) *Drosicha* (*Monophlebus*) *stebbingi*—

144 hours after treatment : Parathion>BHC>Aldrin>Chlordane> DDT

(iv) *Bagrada cruciferarum* F.—

(*a*) 18 hours after treatment : Parathion>BHC>DDT> Aldrin> Chlordane

(*b*) 36 hours after treatment : Parathion>BHC>Aldrin>DDT> Chlordane

(v) *Pyrilla* sp.—

(*a*) 26 hours after treatment : Parathion>BHC>DDT>Aldrin> Chlordane

(*b*) 50 hours after treatment: Parathion>BHC>Aldrin>DDT>Chlordane

(*c*) 74 hours after treatment: Parathion>DDT>BHC>Aldrin>Chlordane

(vi) The comparative toxicity of six fumigants to khapra larvae (*Trogoderma granaria*) on the basis of the graphically determined M. L. D. (Median Lethal Dose) values based on mortality counts taken 7 days after 24 hours exposure was found to be Hydrogen cyanide>Methyl bromide >Carbon disulphide>Ethylene dichloride>Chlorosal>Carbon tetrachloride.

(vii) Gamma BHC, toxaphene and aldrin were compared for their toxicity to 1st and 2nd instar nymphs of *Schistocerca gregaria* and the order of toxicity was found to be BHC>aldrin>toxaphene. To the third instar and fourth instar nymphs, BHC appeared to be more toxic on the first one or two days, but later on aldrin proved better.

Besides the bioassay of well established insecticides, the toxicity of six chlorinated terpene products synthesised in the Chemistry Division was compared with technical toxaphene, using *Tribolium castaneum* adults as test insect. Of these, one compound (Chlorinated delta 3 carene) compared fairly well with technical toxaphene.

8. *Effect of modern insecticides on the viability and freedom from pest of stored grains.*—A preliminary experiment was carried out in which twelve different seeds were treated with 10 per cent DDT and 4 per cent BHC dust and a proprietary product containing pyrethrins. .Also 14 varieties of wheat and 2 varieties of gram were fumigated with chlorosol. After treatment, these seed samples were kept under normal conditions and for the normal period of storage, and then examined for their degree of infestation and viability. The results were encouraging but the experiments have to be repeated before reporting the conclusions.

9. *DDT and allied insecticides.*—Studies on the effect of DDT mixed in different doses with soil on the incidence of termite attacking sugarcane showed that termites were present in the plots where as high a dose as 40 lbs. per acre was administered. Persistence of the DDT in the soil is under investigation.

Laboratory sprayings done with emulsions of DDT, BHC and Toxaphene in different strengths with *Diacrisia obliqua* larvae as the test insect showed that only BHC (0·2 per cent) was effective in giving 80 per cent mortality in 2 days against nil in the control for the same period. Results with 1 per cent DDT and 0·25 per cent Toxaphene did not give satisfactory results.

Observations on the persistence of Toxaphene emulsion (0·125 per cent and 0·25 per cent) on maize leaves showed that there was 100 per cent mortality in two days among locust hoppers that were fed with the sprayed leaves of either strength after 7 days of spraying against nil in the control.

The experiment on the control of cotton bollworm showed that spraying of DDT suspension (0·25 per cent) at two weeks interval had harmful effects on the buds and bolls and the control of the bollworms was also really not effective even with these frequent sprayings. Presistence of 0·25 per cent DDT suspension on cotton is under study.

PROGRAMME OF WORK FOR 1953-54.

I. Section of Insect Parasitology

(A) *Fundamental studies on insect parasitism.*—

(i) Bionomics and morphology of *Lestodryinus pyrillae* Kieff. (Dryinidae : Hymenoptera).

(ii) Bionomics and biology of *Ageniaspis pyrillae* Mani and *Cheloneurus pyrillae* Mani.

(iii) Effect of laboratory hosts on the sex-ratio of *Stenobracon deesae* Cam.

(iv) Breeding a DDT resistant strain of *Bracon gelechiae* Ashmd.

(v) Comparative bionomics of three species of parasites of cotton pink bollworm.

(vi) Effect of light on the behaviour of insect parasites.

(vii) Studies on the inter-relationship of the parasites of the cotton bollworm. The degree of incidence of multi-parasitism study of competition between the species.

(B) *Preparation of a catalogue of insect parasites and predators of major pests of agricultural crops in India.*

(C) *Studies on Insect Physiology.*
Factors responsible for the production of winged aphids.

(D) *Apiculture.*

(E) *Biological control of insects.*—

(i) Culture of three new parasites of cotton bollworm (*Apanteles* spp. and *Chelonus* sp.)

(ii) Trials to establish *Bracon gelechiae* in sugarcane and cotton fields.

(iii) Trial of exotic parasites to control San Jose scale in Kashmir.

II. Section of Insect Taxonomy and Morphology

(*a*) Cataloguing of Indian Insects : (i) Tachinidae and Asilidae (Diptera) and (ii) Eumenidae (Hymenoptera) in the series of Catalogue of Indian Insects.

(*b*) Studies on the genitalia of Anobiidae and Ptinidae (Coleoptera) to be continued.

(*c*) A comparative study of the male genitalia of Eumenidae available in the National Pusa Collection.

(*d*) Studies on the genitalia of Thysanoptera from the systematic point of view.

(*e*) Systematic studies on Reduviidae.

(*f*) Systematic studies on Curculionidae of India.

III. Section of Ecology and Toxicology

(*a*) Ecological and Toxicological studies on *Hieroglyphus nigrorepletus.*

(*b*) Loss of water from insects' body : water balance in insects.

(*c*) Studies for constructing biometers.

(*d*) Bioassay of insecticides.

(*e*) Effect of temperature on insects' susceptibility to insecticides.

(*f*) Studies on the phytotoxicity and persistence of insecticides under field conditions.

(*g*) Effect of chemical treatment on viability of different grains.

(*h*) I. C. A. R. Scheme on DDT and allied insecticides.

IV. Insect Vectors of Virus Diseases

(i) Studies on collection of sucking fauna from chilli, tomato, *sesamum*, etc.

(ii) Transmission experiments with vectors.

V. Miscellaneous and Routine Observations

(1) Observations on Indian insects of economic importance.

(*a*) Pests of crops at I. A. R. I. and in the neighbouring villages with a view to assisting local cultivators in controlling the pests (including rodents) under the Delhi Intensive Cultivation Scheme.

(*b*) Fruit pests.

(*c*) Pest of potato.

(*d*) Pest of sugarcane and their natural enemies.

(*e*) Predators and parasites in general.

(2) Studies of immature stages to fill up certain lacunae.

REPORT OF THE DIVISION OF MYCOLOGY AND PLANT PATHOLOGY FOR THE YEAR 1952-1953

(Dr. R. S. Vasudeva)

SECTION OF PLANT PATHOLOGY

1. Wheat

(*a*) *Rust* (*Puccinia graminis tritici* (Pers.) Erikss. & Henn., *P. triticina* Eriksson, *P. glumarum* (Schmidt) Erikss. & Henn.).—Studies on the physiologic races of black, brown and yellow rusts were continued. In all 154 collections of rusts from different parts of the country were analysed and races 15, 21, 24, 34, 40 and 42 of black rust, races 10, 11, 20, 26, 63, 106,107 and 108 of brown rust and races 19, 20, A, D and E of yellow rust were obtained. Races 21 and 34 of black rust, races 20 and 63 of brown rust and race 19 of yellow rust were found to be most common and widely distributed throughout the country.

A search for the collateral and alternate hosts for the rusts was continued in the hills of Bombay, Mysore, Madras, North Travancore and Simla. About 153 collections of the rusts on wild grasses were made, but none of them was found to belong to any of the three wheat rusts. Rust collections from *Vulpia myuros* and *Briza minor* on analysis confirmed the earlier findings that the rust on these grasses is *Puccinia graminis avenae*. *Vulpia myuros* was further tested against individual races of black rust, but it did not take infection.

Further evidence of the oversummering of black and yellow rusts on volunteer wheat plants was obtained from the Simla hills (8,000-9,000 ft. altitude) and of brown and yellow rusts on the summer crop in the Nilgiri hills (6,500 ft. altitude).

Five Afghanistan rye varieties (Af. 31-A, Af. 32-1, Af. 32-2, Af. 32-3 and Af. 34-2A) were found infected with *P. graminis tritici* under field conditions at the Wheat Breeding Sub-Station, Simla. Collections from two other rye varieties at I.A.R.I. yielded race 21 of black rust of wheat.

Sixtyone rust nurseries were established at different places with a view to studying the annual variations in the rust race flora of the country and also to find out the date of rust appearance in relation to the first spore shower. Three wheat varieties (Agra Local, N.P. 4 and a variety local to the tract) were sown in small plots during the wheat sowing season. Slides were exposed in aeroscopes at 55 stations from November to March and at the remaining six stations, which were situated near the foothills, from August to March. Out of 61 such stations, 20 did not communicate the dates of rust appearance for any of the three rusts. Out of the remaining 41 stations, 18 gave data for black rust, 19 for brown rust and 12 for yellow rust appearance. The spores of black, brown and yellow rusts were trapped on the slides exposed at 14, 6 and 5 stations, respectively, at least one week before the date of appearance of the rust concerned as reported by different stations.

Out of 42 wheat varieties tested in the seedling stage against individual races of black rust, varieties R. R. 79, E. 1913 and Kenphad 34 proved to be resistant

to all the races. Varieties E. 572, E. 1906, E. 1914, W. 375/S. 128(S), W. 375/81(D) and W. 392/S. 51(S) were resistant to all the races except 15-C. In all, 4,150 plants were tested against individual races and 4,044 plants against a mixture of all the races and promising material selected for further study. As regards seedling resistance to individual races of the brown rust, varieties E. 592, E. 616, E. 2140, Gabo×N. P. 165-Pl. 2, Gabo×N. 4-Pl. 19 and Gabo×N-4-Pl. 45 were found to be resistant. Seven varieties were also tested against races 11(=D), 63 and 106 individually and with a mixture of all the races of brown rust ; but they were found to be susceptible. In the case of yellow rust, 4,624 seedlings of exotic varieties, crosses and selections were tested against either individual races or a mixture of races and promising material selected for future work. During the year under report, more than 18,000 plants in the seedling stage were tested against all the three rusts.

In the adult resistance tests, more than 82,500 plants were examined in the field for their rust resistance after artificial inoculations with a mixture of races of each of black, brown and yellow rusts or with a mixture of all the races of the three rusts. Resistant plants have been selected for further study. Wheat varieties R. R. 79 and E. 1913 were found resistant to black rust and E. 2140 and Gabo ×N. P. 165-Pl. 2 to brown rust both in the seedling and adult stages.

Different agricultural practices and manurial treatments did not show any difference in the rust incidence. At Pusa the infection was uniformly heavy in all the treatments and at Delhi it was light. No significant results were obtained in the experiments to test the efficacy of sulphur and other fungicides for the control of the rusts at Delhi as the infection was very light.

(*b*) *Smut* (*Ustilago tritici* (Pers.) Rostr.).—Out of 54 wheat varieties tested for their resistance to loose smut, 32 remained free from infection by all the three isolates (L_1, L_2 and L_4) of *Ustilago tritici* and may be regarded as promising from the point of view of loose smut resistance. The results so far obtained have given no evidence of physiologic specialization within the fungus, but these results cannot be considered conclusive as most of the differentials did not take infection.

(*c*) " *Tundu* " *Disease* (*Corynebacterium tritici* (Hutch.) Bergey *et al*).—Relationship between the host, the bacterium and the nematode was under study. Histopathological studies revealed the presence of *C. tritici* and *Anguillulina tritici* in the growing points of the infected wheat seedlings. The nematode *Anguillulina tritici* could be cultivated for a short period on plain maize-meal agar in the presence of *Alternaria tenuis*. *C. tritici* appears to be similar to *C. rathayi* which causes an identical disease on *Dactylis glomerata*. Control of the disease by floatation method was successfully demonstrated to the growers. The infection in the treated plots was less than 1 per cent as compared to 5-25 per cent in the plots sown with untreated seed.

2. Barley

(*a*) *Rust* (*Puccinia graminis tritici* (Pers.) Erikss. & Henn. and *P. glumarum* (Schmidt) Erikss. & Henn.).—Seventeen rust collections of barley, obtained from different localities, yielded races 21, 34, 40 and 42 of black rust and race 19 of yellow rust.

Four barley varieties were tested against individual races of black and yellow rusts and 21 varieties against a mixture of races of yellow and black rusts separately

in the seedling stage. No variety was found resistant. In the adult stage, 209 cultures of barley were tested against a mixture of black and yellow rust races separately or with a mixture of races of both the rusts and 198 varieties were found to be resistant. Altogether over 4,000 plants were tested.

(*b*) "*Molya*" *disease.*—The occurrence of a severe disease, resulting in stunting of wheat and barley plants, has been reported from Rajasthan for the last few years. The disease is locally known as "Molya" and seems to be restricted to light sandy soils. The affected seedlings show pronounced chlorosis, turn yellow, and eventually die. Those which survive are stunted in growth and produce very small ears containing shrivelled grain. Gall-like swellings are also formed, usually at the tip of the rootlets and sometimes in the intercalary region of the roots and rootlets. These galls yielded a *Pythium* sp. and a nematode. Pathogenicity tests with the *Pythium* sp. resulted in the stunting of the seedlings, but the characteristic yellowing of the plants, as observed in the field, was not obtained.

3. Sugarcane

(*a*) *Red Rot* (*Colletotrichum falcatum* Went).—A localised epidemic of red rot in certain localities of Jagadhri (Punjab) was reported in some of the popular varieties especially Co. 312. The area was surveyed and collections made for physiologic race study.

Thirty-four isolates of *C. falcatum*, obtained from different cane varieties and localities of Bihar, Uttar Pradesh and Punjab, were tested for their virulence on 10 selected cane varieties of different genetic composition. Little physiological specificity was, however, observed in any of the isolates. In general, the dark coloured isolates were less virulent than the light types. Also, the isolates obtained recently from Punjab and Bihar showed greater virulence than the older ones in stock from the same tracts. Co. 356 gave quite high infection with some of the recent isolates.

In the varietal resistance tests, 225 cane varieties were tested by the plug method with *C. falcatum* isolate No. 244. One variety (Co. 795) was found resistant, 161 reacted as moderately resistant and 63 as susceptible. Likewise, 91 varieties were tested for red rot infection through the nodal regions of cane. Three varieties showed less than 15 per cent infection (resistant), 7 showed 15-30 per cent infection (moderately resistant), 14 showed 30-50 per cent infection (susceptible) and in the remaining 50 the infection ranged from 50-100 per cent (highly susceptible). Eight cane varieties, which had proved to be resistant during the previous tests, were further tested with six most virulent isolates of *C. falcatum*. Two varieties were found to be susceptible, whereas the remaining six continued to react as resistant.

Experiments to study the inheritance of disease resistance for red rot and smut in sugarcane were continued at Coimbatore. Twenty cane varieties of Co. 281 parentage, 28 of Co. 301 parentage, 16 of Co. 349 parentage, 17 of Co. 331 parentage, 92 "G" numbers of final test plot, 32 important commercial varieties of India, 27 foreign varieties which are important parents, 28 newly released Coimbatore varieties (Co. 934 to Co. 961) and 45 *Spontaneum* collections were inoculated for the purpose.

Twenty-five cut and standing canes each of 20 parent and other important commercial varieties were tested against red rot by Abbott's method of inoculation

(cut canes) and by the one followed at I.A.R.I. (standing canes). Thirteen varieties gave higher infection in the first method, 6 showed more infection in the second and only one variety gave equal infection in both the methods. In the experiment to study the beneficial effect of sulphur application at the time of planting on the resistance to red rot, it was found that 5 varieties showed same or practically the same amount of red rot infection in the sulphur-treated and untreated crops, two gave less infection in the treated plots than the control, whereas 3 varieties showed greater infection in the treated plots. *C. falcatum* was readily isolated from the red rot affected setts treated with hot water at 51·5°-52·5°C. for 22 minutes, showing thereby that this method of red rot control is not effective. It has been further found that the mixture of light and dark type isolates is more virulent than either of the two isolates individually. It has been again confirmed that the red rot fungus does not survive in the cane debris which has been composted for about a year. Cultural studies have also been in progress to elucidate some of the factors responsible for variation in *C. falcatum*. The perithecial stage of the red rot fungus, hitherto unrecorded from India, has been successfully produced in culture with some of the Indian light type *C. falcatum* isolates.

(*b*) *Smut* (*Ustilago scitaminea* Syd.).—In the varietal resistance tests, setts of 96 parent and other important cane varieties were inoculated with smut spore suspension and then planted in the field for final observations. Twenty-two varieties showed less than 5 per cent infection, 15 showed 5-15 per cent infection, 11 gave 15-30 per cent infection and the remaining 48 varieties showed 30-90 per cent infection. The first 22 varieties, which showed less than 5 per cent infection, may be considered as resistant.

4. Linseed

Rust (*Melampsora lini* (Pers.) Lev.).—Seven samples of linseed rust, collected from different parts of the country, were analysed which yielded Indian races 1, 3 and 4. Pure cultures of the four Indian rust races were suitably maintained and supplied to scientific workers for the varietal resistance tests. *Linum mysorens* growing wild in Simla Hills, has been shown to be susceptible to *Melampsora lini*.

Twenty-nine varieties and crosses of linseed, different from those tested during the previous years, were inoculated with a mixture of the four Indian races both in the seedling and adult stages ; and 39 varieties in the adult stage only. From the first group, 15 varieties reacted as resistant, 4 as susceptible and the remaining 10 varieties gave mixed reactions. Amongst the varieties that were tested only in the adult stage, 23 proved to be resistant and 9 susceptible, while the remaining 7 gave mixed reactions.

5. Pigeon-pea

Wilt (*Fusarium udum* Butler).—Twenty selected pigeon-pea varieties were tested for wilt resistance both in pots and in wilt-sick plot. Three varieties (N. P. 41, C. 15 W. E. and C. 38-3-1) proved resistant as they did not show any infection either in the field or in the pots ; 5 varieties showed infection in the field but not in pots, whereas the remaining 12 varieties proved susceptible in both the cases.

6. Bajra

Green Ear (*Sclerospora graminicola* (Sacc.) Schroet.).—Germination tests of oospores of *Sclerospora graminicola* were continued. About 10 per cent germination was obtained when the material was exposed to weathering conditions for about 9 months. Soil and leaf decoctions as well as exposure to extremes of temperature did not improve the germination of oospores.

Successful infection of *bajra* seedlings has been obtained in pots by infecting the soil with oospores at the time of sowing, but the incidence of the disease was low. Higher infection (31·4 per cent) was observed when the soil was infected with oospore material placed out in the open for weathering since last February. Out of 108 *bajra* plants, growing in a heavily infected field plot, only six plants showed leaf infection and one of these formed two typical " green ears ".

In a replicated field experiment, the natural incidence of the green ear disease was recorded on different varieties of *bajra*. The local *bajra* variety showed 6 per cent infection, varieties T55, Al/3, Kl, AKPl and No. 207 showed only traces of infection, whereas varieties Co. 1, Co. 2, *Setaria italica* var. *white*, Teosinte and maize N. P. 2 were found to remain free from infection.

7. Antibiosis

Studies on the inhibitory action of *Bacillus subtilis* on *Fusarium udum* and other pathogenic fungi were continued. The loss of antibiotic activity of the culture filtrate of *B. subtilis* on passage through soil was confirmed. Studies indicated that such loss was due to adsorption by the clay particles and that the pH of the soil seemed to play little part in it. A method for the isolation of the antibiotic from the filtrate was developed which consisted in adsorption on to Kaolin and its elution therefrom with ethanol. It has been found to be a thermostable substance, giving positive biuret and Xanthoproteic reactions, and was active at a pH range of 4·5-9·8. It inhibited the growth of *Fusarium udum* on P. D. A. and the germination of the spores of *Alternaria solani* in water at a concentration of 1 : 10000. At higher concentrations, it inactivated *in vitro* the mosaic viruses of Petunia, chillies and Periwinkle (*Vinca rosea*). The antibiotic principle was found to act systemically within tomato plants and reduced the infection caused by *A. solani*.

8. Physiology of parasitism

Work on the study of factors underlying the specialization of parasitism of *Fusarium solani* and *F. fructigenum* has been initiated. The former fungus attacks both potato and apple, whereas the latter attacks only apple. *F. solani* is, however, less virulent on apple than *F. fructigenum*. Enzymic studies have indicated that the quantity of pectinase produced by the two fungi accounts, at least partially, for the differences in their parasitism. It has also been found that the endoenzyme preparation from each fungus is more active than its exoenzyme.

9. Fungicides

Replicated field experiments were conducted to determine the relative efficacy of several commercial fungicides on the emergence, stand and yield of *bajra*, maize,

barley and wheat. It was generally indicated that the fungicidal seed dressing improved the emergence of maize, wheat and barley ; but it did not have any appreciable effect on their tillering, height and yield. In the case of *bajra*, however, treatment with Arasan, Ceresan and copper carbonate gave better yields than the control.

10. Assessment of damage

The loss in yield due to linseed rust at different intensities of infection was determined for varieties N. P. 1, N. P. 11 and N. P. 12. With moderate and heavy infection in N. P. 1, the losses in yield on 100 plant basis were 38·2 and 43·8 per cent and, on 1,000 grain weight basis, 33·8 and 35·4 per cent respectively. Corresponding figures for the variety N. P. 11 were 75 and 92·5 per cent and 37·9 and 66 per cent ; and for N. P. 12, 28 and 77·6 per cent, and 2·7 and 21·6 per cent respectively. In the case of sugarcane smut, it was observed that the smut infection caused 30·62 and 40·49 per cent reduction in yield in Co. 312 and Co. 313 respectively when the setts were infected at the time of planting. Much greater reduction in yield was observed when setts from smutted canes were used for seed, the corresponding figures for reduction in yield in Co. 313 being 73·3 per cent.

11. Miscellaneous

(*a*) *Microflora of stored seed grains.*—The ecto and endophytic microflora of pulse (*mung*, *urid* and bean) and vegetable seeds (chilli, onion, cucumber, cabbage, cauliflower, brinjal and tomato) seeds were studied. Spores of *Alternaria*, *Cercospora*, *Fusarium*, *Helminthosporium*, *Acrothecium*, *Diplodia* and some other fungi were observed in seed washings. When isolations from these seeds, after surface sterilization, were made on 4 media (2 per cent Malt extract agar, P. D. A. at pH 4·5 and 7·5 and Smith Humfeld agar) a species of *Rhizopus* was commonly obtained. An *Alternaria* sp. was also isolated from both pulse and vegetable seeds.

The beneficial effect of fungicidal seed dressing treatment on germination and the growth of seedlings was tested with Ceresan, Arasan, Semesan, Semenon, Spergon and SR 406. Most of the fungicides checked the pre-emergence injury which resulted in better germination. The vigour of the seedlings was also improved.

(*b*) *Leaf spot of brinjal.*—This disease was observed to cause considerable damage to the *brinjal* plants at I.A.R.I. An *Alternaria* sp. was isolated from the affected leaves and fruits. It gave positive infection on potato, tomato, *brinjal*, *Lycopersicon pimpinellifolium* and *Hyoscyamus niger* ; but typical concentric rings, as produced by *Alternaria solani*, were not formed. Comparative studies with *A. solani* and other *Alternaria* spp. showed it to be similar to *A. tenuis* Nees morphologically. But because of its pathogenic nature it appears to be a new *form* of the fungus.

(*c*) *Bacterial brown rot of potatoes.*—Isolates from the diseased material from Assam, Punjab, Bengal, Bombay, Madras, Uttar Pradesh and Bihar were used in a comparative study to ascertain the existence of strains of *Pseudomonas solanacearum* in India, which showed that there are at least two strains of the pathogen occurring in the country. In the first group were included Uttar Pradesh and Bengal isolates, whereas the second group consisted of the remaining isolates. The latter

group was, however, very heterogenous and the isolates from different States differed in some minor characteristics.

(*d*) *Bacterial leaf spot of pomegranate.*—This is a new disease and is caused by a *Xanthomonas* sp. The organism was compared with *Xanthomonas carotae* and some other related species and was found to be different. It appears to be a new species.

(*e*) Twenty exotic wheat varieties, which had been suspected to be affected with Bacterial black chaff disease last year, were inoculated with the bacterium isolated from the diseased wheat plants with negative results.

Section of Plant Viruses

12. Bottlegourd

Mosaic (*Cucumis* Virus 2C).—The disease was successfully transmitted with Red Pumpkin beetles (*Aulacophora foveicollis*), but the percentage of infection obtained was very low (4 per cent). It was further found that the virus freely mutates under favourable environmental conditions and the mutant appears in the form of yellowish irregular spots on bottlegourd leaves. The type virus and the mutant did not significantly differ from one another in their physical properties, but the latter was found to be comparatively more virulent.

13. Sannhemp

Mosaic.—The disease could not be transmitted to *Capsicum annuum* by juice inoculation, but *Petunia hybrida* was found to be a symptomless carrier. The virus produced local necrotic lesions on Guar (*Cyamopsis tetragonoloba*). *Utetheisa pulchella* and *Bemisia tabaci* could not transmit the virus. The virus was found to be infective in the sap stored for 301 days at 6°-10°C. Host-range of Southern Sannhemp Mosaic Virus was also being studied.

14. Hibiscus rosa-sinensis

Leaf curl.—The disease was successfully transmitted to *H. rosasinensis*, *Althea rosea* and *Abelmoschus moschatus* by grafting and to *A. esculentus*, *A. tuberculatus* and *A. manihot* with white flies (*Bemisia tabaci*). The virus differs from tobacco leaf curl, yellow vein mosaic of *bhindi* and cotton leaf curl viruses.

15. Tomato

(*a*) *Leaf curl.*—Thirty-three different varieties of tomato and five different species of *Lycopersicon* were tested for their resistance to the disease. Almost all the varieties of tomato tested were found to be susceptible, as also the different species of *Lycopersicon*, with varying degrees of susceptibility, both by grafting and through insect agency.

(*b*) *Necrosis.*—The disease could not be transmitted by sap inoculation. It was, however, transmissible by grafting to tomato, White Burley tobacco, *Datura stramonium* and *Capsicum annuum*.

16. Bhindi

Yellow-vein mosaic.—The disease was transmitted to *Abelmoschus manihot*, *A. moschatus*, *A. ficulneus*, *A tuberculatus* and *Hibiscus cannabinus* both by grafting and with *Bemisia tabaci* but *H. sabdariffa* took infection only by grafting. One hundred and seventeen *bhindi* varieties and hybrids, grown in the Botany Division, were found to be susceptible to the disease. *Althea rosea* was found to be an important alternative host for the virus. The virus at Delhi, unlike at Poona, showed vein thickening on *A. manihot* and was readily transmitted by white flies to *H. cannabinus*.

17. Chilli

(*a*) *Mosaic.*—The disease is sap transmissible. Host-range and properties of the virus are being studied. The disease was transmitted by *Aphis gossypii* to 5 chilli plants out of 40 under test.

(*b*) *Leaf curl.*—The disease was transmitted by grafting, but not by juice inoculation. In addition to chilli, the virus was successfully transmitted to *Lycopersicon esculentum* and *Nicotiana tabacum*.

18. Brinjal

(*a*) *Mosaic.*—The virus at Poona was found to be sap transmissible. The Dilution-end-point of the virus lies between 1 : 500 and 1 : 1,000 and its Thermal-death-point between 60° and 70°C. The virus after one hour's interaction with 90 per cent ethyl alcohol at 35°C. was rendered innocuous. As regards longevity the virus was found to remain infective even after 15 days' storage at 35°F. Seven *Brinjal* varieties (Large Purple, Pusa 1, Giant of Banares, Tall Large Round, Manjri Round, Surat Round and American Purple Round) tested proved to be susceptible to the disease. *Physalis peruviana* and *Vinca rosea* remained uninfected. Previous results of transmission of " Delhi virus " with *Empoasca devastans* could not be confirmed in repeated tests.

19. Sesamum

(*a*) *Phyllody.*—Eight sesamum varieties (N. P. 7, N. P. 12, N. P. 29 and Selections, H,N,O,P and S) were found to be susceptible to the disease by grafting. *Bemisia tabaci* and a species of *Empoasca* could not transmit the disease, whereas *Eutettix phycitis* transmitted the disease in 1 out of 48 plants under test. Field observations showed that the disease was more severe in an early-sown crop than in the late-sown one.

(*b*) *Leaf curl.*—The disease was successfully transmitted to sesamum variety N. P. 6 by grafting and with *Bemisia tabaci*.

20. Pumpkin

(*a*) *Mosaic.*—Host-range and physical properties of the virus were studied. The virus did not withstand treatment with 90 per cent ethyl alcohol at 35°C. even for one hour. It was also inactivated by heating at 50°C. for 10 minutes. The virus was successfully transmitted by *Aphis gossypii*, but not by Red pumpkin beetles (*Aulacophora* sp.).

(*b*) *Yellow-vein mosaic.*—The disease has been transmitted to *Cucurbita pepo* and *Cucumis sativus* through viruliferous white flies.

21. Carica papaya

Mosaic.—Host-range of the virus was studied and the following nine plant species in the family *Cucurbitaceae* were successfully infected by sap inoculation : *Cucumis sativus*, *C. melo*, *Cucurbita moschata*, *C. pepo* var. *medullosa*, *Citrulus vulgaris*, *C. fistulosus*, *Luffa acutangula*, *Lagenaria vulgaris* and *Trichosanthes anguina*.

22. Cotton

"*Small-leaf*" *disease.*—A sudden out-break of the disease was observed in Hagari cotton (*G. herbaceum* var. *frutescens*) and a cross between RK 19 and NS 12 at the College Farm in April, 1953, almost 12 years after the disease last made its appearance in Poona in 1940. Out of the five varieties of old world cottons tested for their resistance to the disease, four (Bani, Wagad, N.M.D. and Jarila) were infected by grafting.

23. Banana

Mosaic.—Transmission of the virus by sap was obtained only in *Cucumis sativus*. Insect transmission tests with *Aphis gossypii* and *Myzus persicae* were continued, but the insect vector could not be established.

24. Maize

Mosaic.—The virus was transmitted by *Aphis maidis* to 7 plants of maize, by *Aphis gossypii* to 2 plants of maize and by *Myzus persicae* to 2 plants of maize and 1 of *jowar*.

25. Gooseberry

Mosaic.—Preliminary results have shown that mosaic of gooseberry is probably caused by the same virus that produces distortion mosaic in *Datura inoxia*. Host-range of the virus was studied and so far gooseberry, *Vigna sinensis*, *Nicotiana tabacum* and *Capsicum frutescens* have been infected when inoculated with the extracted juice from the leaves of infected *Datura inoxia*.

26. Development of new strains, serological relationship and cross immunity studies

Experiments on cross protection in White Burley tobacco with Dolichos Enation Mosaic Virus and Tobacco Mosaic Virus showed that when tobacco plants were inoculated first with Tobacco Mosaic Virus and then reinoculated on the same leaves after 2 days' interval with Dolichos Enation Mosaic Virus, both the viruses freely infected tobacco. But when the interval between the two inoculations was 4 days or more, Dolichos Enation Mosaic Virus did not become systemic in tobacco plants.

Mutant obtained from *Curumis* Virus 2C was being studied. Strains of tobacco mosaic virus naturally occurring in Simla hills were also under study.

27. Isolation and purification of plant viruses and study of their properties

Attempts to isolate and purify the mosaic viruses of bottlegourd and *brinjal* remained unsuccessful.

(*k*) Studies on microbial antagonism and physiology of fungal parasitism.

(*l*) Bacterial diseases of plants including "Tundu" disease of wheat, leaf spot of pomegranate and leaf stripe diseases of sugarcane, maize and sorghum.

(*m*) A survey of nematode diseases of plants and vegetable diseases.

II. Plant Virus Investigations

(*a*) The following viruses will be studied :—

Mosaic viruses of Bottlegourd, *Carica papaya*, *brinjal*, *Bhindi*, banana, gooseberry, *Cucurbita moschata*, maize, chilli and Sweet Rocket; Yellow-vein mosaic of pumpkin, Dolichos enation mosaic, Yellow mosaic of *Cajanus cajan*, leaf-curl and necrosis in tomato, "Small-leaf" disease of cotton, Mango malformation, Sesamum and Sann-hemp phyllody, leaf-curl and necrosis in chilli.

(*b*) Virus-vector relationships of the following viruses will be studied :—

Mosaic of *Carica papaya*, pumpkin, bottlegourd, *brinjal*, sugarcane, maize, chilli and groundnut, Yellow-vein mosaic of pumpkin, sesamum phyllody and "Little-leaf" of *brinjal*.

(*c*) Isolation and Purification of *brinjal* mosaic virus.

(*d*) "Katte" disease of cardamom and its control in Bombay.

(*e*) Survey of plant virus diseases.

III. Mycological Investigations

(*a*) Study of the Fungal Flora of Delhi. Taxonomic study of new collections and unidentified collections available in the Herbarium Crypt Ind. Orient. Preparation of exsiccati sets of Indian Fungi and list of Fungi deposited in Herbarium.

(*b*) Maintenance of Indian Type Culture Collection of Micro-organisms and their history sheets and study of methods for preservation.

(*c*) Additions to and maintenance of the Herbarium.

(*d*) Identification of Fungi and disease specimens.

IV. Miscellaneous

(*a*) Maintenance of Host Index of Fungi; preparation of card indices of species of Fungi represented in India will be continued.

(*b*) Routine and Advisory, Post-graduate Teaching and Training, and assistance and advice to Indian Council of Agricultural Research, Indian Central Sugarcane Committee and Indian Central Oilseeds Committee and Intensive Cultivation Scheme, Delhi State in mycological and plant pathological matters. Also Co-ordination of mycological and plant pathological research.

REPORT OF THE DIVISION OF AGRICULTURAL ENGINEERING FOR THE YEAR 1952-53.

(Shri R. V. Ramiah.)

General

(*a*) The office and the workshop buildings of the Division were not built during this year also and for the lack of proper accommodation and equipment, the research work was on a restricted scale. The construction of a workshop building has recently been started but in the meanwhile the difficulties have further been enhanced due to the shifting of the workshop and stores to the Chandman Sheds where there is no electric power. The major part of the activities of this Division were the maintenance, servicing and repair of machinery belonging to the other Divisions, particularly that of the Division of Agronomy. The Agricultural Sub-Station at Karnal and the Botanical Sub-Station at Pusa (Bihar) were given technical advice, whenever they needed.

(*b*) The following machines and implements were received for tests and trials during the year :—

1. Vijoya Plough . . .	From Messrs. Cossul & Co., Kanpur.
2. Care Plough . . .	
3. Olpad Thresher . . .	
4. Bund Former . . .	From Messrs. P. S. G. & Sons, Coimbatore.
5. A modified pedal operated thresher for wheat, oats, etc.	From Messrs. American Spring and Pressing Works, Bombay.
6. Jai Hind Plough . .	From Messrs. Unique Metal Works, Aligarh.
7. Phataphat Chaff-Cutter .	

(*c*) At the instance of the Ministry of Food and Agriculture, a Conference of the State Agricultural Engineers and Manufacturers and Dealers of Agricultural Implements was held in the month of January, 1953 under the auspices of the Indian Council of Agricultural Research. The Head of this Division acted as the Secretary of the Conference and Dr. P. S. Dehsmukh, Minister of Agriculture, Government of India, presided. The conference considered the ways and means of improving the implements and implement industries and recommended certain steps for the same. The I. C. A. R. in consultation with the Head of this Division are taking actions to implement those recommendations.

(*d*) A detailed scheme has been submitted to the Government of India for the formation of a Central Museum of Agricultural Implements at the I. A. R. I. Circulars and letters have also been sent to the various State Governments, as well as the implement manufacturers to donate or exhibit their popular and useful implements. Many offers have so far been received but there is a lack of proper storage and display room for the implements. Some country ploughs and small implements have been already collected.

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Demonstration of Tractors & Implements

(*a*) A demonstration of various types of tractors and tractor implements, was organised by this Division and was held on the 9th January 1953, in the Todapur area of the I. A. R. I. Farms, in the presence of a large distinguished gathering including the agricultural engineers of all States of the Indian Union and several M. Ps. Most of the prominent tractor dealing firms in India took part in the demonstration for about four hours.

(*b*) *Indian Made Tractor.*—One of the two tractors manufactured in India, was demonstrated in the Todapur area of our farms. The tractor was manufactured by Messrs. Howrah Trading Co., Calcutta and tried at the instance of the Ministry of Food and Agriculture in the presence of some engineers of C. T. O. and a few F. A. O. officials. A single furrow plough similar to a country plough was hitched behind the tractor.

(*c*) *'Fiat' Crawler Tractor.*—Messrs. Kamani Engineering Corporation of Bombay, the sole distributors of 'Fiat' tractors in India, arranged for a demonstration of two 55 H. P. 'Fiat' Crawler Tractors on the I. A. R. I. Farm. A large number of distinguished personnel including Shri Rafi Ahmed Kidwai, Central Minister for Food & Agriculture attended the demonstration. At the end of the demonstration the tractors were presented to Shri Kidwai, who accepted the gift on behalf of the Government of India.

RESEARCH AND FIELD TRIALS

Tractor Tests

(i) *David Brown Tractor.*—A David Brown 4-cylinder, diesel tractor equipped with hydraulic lift was tested in the field as well as in the laboratory. The tractor was run for a total number of 50 hours. During the tests it was found that the tractor was suitable for light soils for ploughing upto a depth of 6″—8″. For ploughing harder soils with 1 per cent moisture content, the wheels should be filled with water and weights added to it. With air in the tyres, the wheel slippage was found to be 25 per cent but this was reduced to 11 per cent by filling up the tubes with water and adding weights.

The following are the performance of the tractor with water filled in wheels and with wheel weights :—

	Ploughing	Discing
Depth	8″—8½″	2½″—3″
Fuel consumption in gallons per hour	0·76	0·64
Acre per hour	0·66	2·41
Gear used	1st high	1st high

The hour meter of the tractor has no reference to the time kept by a regular clock. It is only to indicate the frequency at which servicing of the tractor should be done and has reference to the total revolutions of the engine.

(ii) *Deutz Tractor.*—Two models of Deutz Tractors made in Germany were tested in the workshop and fields at the instance of Messrs. East Asiatic Co. (India) Ltd., Delhi. One of them is powered by an *air-cooled* 2-cylinder 30 H. P. diesel engine and the other by an *air-cooled*, single cylinder, 15 H. P. diesel engine. Both tractors were found satisfactory and suitable for our climatic conditions, but the following alterations are suggested :—

(*a*) The metric system of the units of measurement should be changed to conform to the prevailing Indian standards of measurement in feet and inches.

(*b*) The position of the outlet of the silencer should be changed slightly to make the exhaust gases escape clear of the wheels.

(*c*) The locations and heights of the trailer hooks, fixed draw-bar, P. T. O. and belt pulley do not at present conform to the British and American standards and hence the interchangeable character of the implements cannot be maintained unless they are changed.

The data of the performance of the tractors, collected during the tests are given below :—

Model of tractor	Details	Ploughing		Discing	
		Without Weight	With 164 Lb. of weight on front axle	Without Weight	With wt. of 164 Lbs. on front axle
30 H.P. Tractor	(*a*) Depth	7″—8″	6″—7″	3½″	3½″
	(*b*) Acre/hr.	0·33	0·60	1·68	3·00
	(*c*) Fuel cons. in gall/hr.	0·59	0·66	1·18	1·18
	(*d*) Gear used	2nd at full throttle.	2nd & 3rd	3rd at full throttle.	3rd at full throttle.
15 H. P.	(*a*) Depth	6″—7″	..	3″	..
	(*b*) Output in acre/hr.	0·34	..	1·48	..
	(*c*) Fuel cons. in gall/hr.	0·40	..	0·52	..
	(*d*) Gear used	3rd at full throttle.	..	2nd at full throttle.	—

Trials of Disc Harrows

(i) *18″ Allis-Chalmers Disc Harrow (24 Discs).*—The preliminary tests of this disc harrow was carried out on light sandy loam soil. The discs were drawn by the

Allis-Chalmers Tractor and found to be working satisfactorily. The results of the tests are given below :—

Depth of cut	3″ (approx.)
Draft	8 cwts. or 896 Lbs.
Duration of trial	2·50 hours
Area disced	2·50 acres
Fuel consumption—	
Gallon per acre	0·80
Gallon per hour	0·80

(ii) *Evona Disc Harrow.*—The Evona Giant Disc Harrow, imported from New Zealand, was hitched behind a Caterpillar D4 Tractor and put into operation. The implement was found to be working satisfactorily. Both ploughing and discing can be done with it in one operation. The following are the data of its trial :—

Depth of cut	Fuel consumption per hour of the tractor	Output in acres per hour
7″—8″	2·00 gallons (approx.)	0·975

Trials of Different Ploughs

(*a*) *Tractor Ploughs.*—Four tractor ploughs of different make and design have been tested for the preparation of seed bed in sandy loam soil with low moisture content. It will be seen from the data presented below that the plough ' A ' is most suitable for soil conditions in Delhi :—

Type of plough	Percentage of inversion of soil	Pulverisation of soil	Pulverisation after first discing	Pulverisation after second discing
A	75 per cent	100 per cent	100 per cent	100 per cent
B	50 ,,	50 ,,	75 ,,	90 ,,
C	100 ,,	40 ,,	50 ,,	75 ,,
D	40 ,,	75 ,,	40 ,,	60 ,,

NOTES.—A=Massey Harris 12″, 3 furrow Plough (USA).
B=Elite Plough 12″, 3 furrow (UK).
C=T. N. T. Plough 12″, 2 furrow (USA).
D=Ferguson Plough, hydraulic operated, 12″, 3 furrow (UK).

The best results obtained are designated as 100 per cent.

(*b*) *Mould Board Ploughs*—(i) *CARE Plough.*—A 'CARE' mould board plough received from Messrs. Cossul & Co., Kanpur was tried in the sandy loam soil of the I. A. R. I. Farms. The mould board of the plough is made of mild steel and share and the land side are made of high carbon steel while the body is made of cast iron. The performance of the plough was found satisfactory. It is little heavier than the Allahabad and similar ploughs in use in the North.

(ii) *Jai Hind Plough.*—A Jai Hind mould board plough supplied by M/s. Unique Metal Works, Aligarh for tests, was tried on a sandy loam soil with moisture content of 1·60 per cent in the farms of the I. A. R. I. This plough was also found to be suitable. The performance data are given below :—

Name of plough	Furrow		Draft in Lbs.	Speed of bullocks M. P. H.	Output per hr. in acres
	Width	Depth			
Jai Hind	7″	3½″	207·50	1·64	0·12

(*c*) *Country Ploughs.*—Out of the collection of country ploughs at the I. A. R. I. from different States, seven were tested at the Botanical Sub-station at Pusa (Bihar). The ploughs were tested on a soil containing 8·02 to 12·26 per cent of moisture. The Bellary plough was found to be the best among the lot as it ploughed to a depth of 7″ making 8½″ wide furrow with a draft of 293 lbs. The Warrangle and Patna ploughs came second and third respectively. The following are the test figures of the different ploughs :—

Origin or name of the plough	Furrow		Draft in Lbs.	Speed of bullocks M. P. H.	Draft in Lbs. per sq. inch of furrow
	Depth	Width			
Bellary	7″	8½″	293	1·43	4·90
Warrangle	6″	8″	268	1·52	5·58
Patna	5″	8″	260	1·61	6·50
Ujjain	4½″	5½″	167	1·76	6·74
Muzaffarpur	4½″	6½″	205	1·75	7·00
Sagar	4½″	6″	208	1·55	7·70
Raichar	4½″	7″	245	1·68	7·90

(*d*) *Double Plough.*—The frame work of the 'Double Plough' has now been modified to make it lighter in weight. The flat iron frame previously designed by this Division, has been replaced by a wooden one and consequently the total weight of the plough has come down to 60 Lbs. from 85 Lbs. The plough with the modified wooden frame was tried on a hard sandy loam soil and was found to withstand the loading. The draft was recorded to be 260 Lbs. at a depth of 4″.

Seed Drills

(*a*) *Trial of Maize Seed Drill.*—A single row seeding attachment to a country plough for sowing maize seeds, developed by this Division was tried in the field under the actual working conditions. The performance was satisfactory. The machine can be handled easily by the ploughman without affecting the ease in driving the bullocks. It was observed that the sowing could be done at the rate of 3 acres per day. The seed rate while sowing in rows 2′-0″ apart was 20 Lbs. per acre.

(*b*) *Jute Seed Drill.*—A four row seed drill for sowing jute seeds has been designed and manufactured in the Division. The preliminary tests of the machine in field have been completed and the results are found to be satisfactory.

The drill is suitable to be drawn by a pair of bullocks and has got 4 furrows, having 12″ space in between each. The seed rate has been observed to be 2·6 Lbs. per acre. The seed dropping machanism drops 3-5 seeds after every 4″. One acre of land can be sown with this drill per hour. The seed rate can be increased by changing sprocket wheels.

Threshers

(*a*) *Burclover Seed Threshing.*—A small machine, designed and manufactured in this Division run by a ¼ H. P. electric motor, was tried for threshing seeds of Burclover grass. For collecting comparative data of output and cost of threshing, a man was engaged simultaneously to thresh out seeds by the usual method of hand beating. The comparative figures are given below :—

Method of threshing	Total hrs. worked	Total output of clean seeds	Cost of threshing	Cost per Lb. of threshing in Rs.
			Rs. a. p.	Rs. a. p.
Hand beating	2 hours.	0·25 Lbs.	0 6 0	1 8 0
Machine with ¼ H. P. motor	2 hours (excluding 1 hr. for hand winnowing).	2·50 Lbs.	0 12 6*	0 5 0

It is clear from the above data that the threshing with machine is cheaper and quicker than by the hand beating.

(*b*) *Experiments on Paddy Threshing.*—Experiments for collecting comparative data on different methods of paddy threshing, were conducted at the Agricultural Sub-station, Karnal, with three different types of threshers such as, the large Danish Thresher, " Otaka " power operated Japanese thresher and " Akshat " pedal operated thresher (Indian made) and also with the conventional method of beating grains by manual labour. The results of the experiment are given below in brief :—

(i) *Large Danish Thresher.*—The thresher was run by an Allis-Chalmers tractor using Kerosine oil as fuel. The thresher was imported from Denmark and was previously tried at the Institute for threshing wheat, oats and peas. It was tried with paddy for the first time at Karnal and gave an output of 270 Lbs. of grain without breakage per hour and 282 Lbs. per gallon of fuel consumed. The size of the straw obtained after threshing was long and needed to be chopped up for feeding the cattle.

(ii) " *Otaka* " *Thresher.*—This thresher which had recently been imported from Japan, was also run by an Allis-chalmers tractor. It produced 108 Lbs. of clean paddy in an hour and 120 Lbs. per gallon of fuel consumed by the tractor. The breakage of kernels were very little. The straw came out in small sizes which are suitable for feeding the animals without chopping.

* Includes the cost of winnowing, electricity, labour and depreciation for the actual time of work.

(iii) " *Akshat* " *Thresher.*—The performance of this thresher was similar to those of the Japanese pedal operated thresher of which this is an exact copy produced by M/s. American Spring and Pressing Works, Bombay. The cost of threshing with this thresher has been calculated as Rs. 13-13-4 per acre of paddy crop.

(iv) *Conventional Method.*—The conventional method of paddy threshing is the beating of grains by manual labour. The output by this process was 4 experimental plots of 0·025 acres per day of 8 hours with 2 women labourers. The cost of threshing was Rs. 15 per acre.

(*c*) *Threshing wheat by a tractor and disc harrow.*—Some experiments were conducted in a group of Delhi villages in threshing grain with tractor and a disc harrow instead of bullocks. The threshing was done in the same manner as that by bullocks by trampling over a heap of grains spread over the threshing floor. It was observed that an output of 50-80 maunds of wheat could be obtained in 10 hours by using a 15 DBHP tractor and a suitable disc harrow at a cost of Rs. 35-40 per day including depreciation, fuel, lubricant, interest and labour charges. It was also observed that this method of threshing produces finer quality of ' Bhusa ' and the grains are not damaged in any way.

Modification of the hand operated Rotary Screen

A hand operated rotary screen which was designed and fabricated by this Division some time back and worked satisfactorily for sieving manures from the town refuse dumps, has been modified with a view to facilitating its quick transport. The modified model is built entirely of steel with a steel frame instead of a wooden frame. Arrangements for detaching the rotating screen at a short notice have also been made. Although there is no difference in the output between the old and the modified machines the following advantages were obvious in the new model :—

(*a*) Ease in working.

(*b*) Less frequent repairs and

(*c*) Quick transfer from place to place by two workmen.

Efficiency tests of the Circular Mhote

Some experiments on the model of a Circular Mhote, drawn by a single bullock and used in Madras State, were carried out to determine its efficiency with different loads. The figures of percentage of efficiency with different loads and drafts are given below. The turning radius of 10′-6″ and the effective lift of 12′-0″ remained constant in all cases :—

Load	Draft	Efficiency
6 gallons or 60 Lbs.	100 Lbs.	23·80 per cent
8 gallons or 80 ,,	117 ,,	24·84 ,,
10 gallons or 100 ,,	135 ,,	26·80 ,,
12 gallons or 120 ,,	150 ,,	28·16 ,,

In other set of tests, the effective lift was increased to 27′-0″ instead of 12′-0″ by adding a differential pulley block in the middle of the rope. Figures presented below are of the draft and calculated efficiency at this height with different loads. The turning radius remained the same as in the previous test :—

Load	Draft	Efficiency
3 gallons or 30 Lbs.	88 Lbs.	13·80 per cent
4 gallons or 40 „	112 „	14·60 „
5 gallons or 50 „	135 „	15·20 „
6 gallons or 60 „	150 „	16·40 „

The experiments on this Mhote are being continued.

Experiments on Persian Wheel Bearings

Experiments on adapting ball bearings in place of brass bush bearings in the Persian Wheel have been conducted. The pull required in operating the wheel at its normal load is 62 Lbs. When ball bearings were fitted to it the pull required to operate the wheel at the same load and speed was 61 Lbs. With brass bush bearing, the reduction of effort was, therefore, only one Lb. Considering the cost of a set of ball bearing and its subsequent fitting and maintenance charges, its use with a Persian wheel is not recommended.

Trial of Chaff Cutter

A new type of chaff cutter manufactured and supplied by Messrs. Unique Metal Works, Aligarh to this Division for tests was tried by both hand and power. The chaff cutter was found suitable for cutting dried fodder for cattle feed. The following are the test figures :—

Method of operation	Name of fodder cut	Output per hour
Hand	1. Dried Jowar	280 Lbs.
	2. Dried Maize	273 „
Power	1. Dried Jowar	588 Lbs.
	2. Dried Maize	604 „

Some modifications have been suggested for its improvement.

Study of Paddy Cultivating Implements

A study of the Japanese and other implements suitable for production of paddy was made at the Central Rice Research Institute, Cuttack. After carrying out

trials of several implements and studying the practical problems faced in the fields, the following implements have been designed and manufactured :—

1. A 'V' shaped steel plough.
2. An improvement of Orissa Plough.
3. A transplanting sledge.
4. Transplanting tray.
5. A table pattern threshing screen.
6. Wooden threshing roller.
7. Three row weeder.
8. A single row rotary weeder.
9. A six row weeder.
10. A light threshing Screen.
11. A Sevagram type chaff cutter.

All the above implements were tried and demonstrated before the Director and Officers of the C. R. R. I. at Cuttack. The threshing roller, six row weeder and the transplanting sledge did not, however, prove successful. Other implements worked satisfactorily. Small models of all these implements have also been fabricated.

A New Puddler

An improved type bullock drawn puddler has been designed and manufactured. The puddler does the job of ploughing as well as puddling simultaneously. The preliminary trials of the implement were carried out at the Extension Centre at Nilokheri and were found satisfactory. The cost of the implement has been estimated to be Rs. 50 each.

Intensive Cultivation

(*a*) Demonstration of a multi-purpose Allahabad Seed Drill and Double Plough was held in the village of Nangloi. The Double Plough when drawn by camels, gave satisfactory results and the villagers were interested to use it as a camel plough. Three ploughs were distributed among the farmers.

(*b*) Demonstration of threshing by a tractor and disc harrow was held in the village of Nangloi, Nilothi and Najafgarh. The villagers were much satisfied with the performance. The bullock drawn Olpad thresher was also demonstrated. Some of the villagers expressed their willingness to adopt the Olpad thresher.

(*c*) Twelve persons were sent to the village of Nilothi for tree plantation.

Extension Work

For popularisation of the Japanese implements for the rice cultivation in the country, one dozen each of the Japanese single and double row rice land weeders were got manufactured by Messrs. Unique Metal Works, Aligarh (U. P.) to whom the models and the drawings of the implement were supplied by this Division. The weeders were supplied to various State Governments, including some Members of Parliament for trials and demonstrations in their respective regions.

PROGRAMME OF WORK FOR 1953-54.

1. Testing of tractors, engines and pumps.
2. Testing of mould board and country ploughs.
3. Continued experiments with Circular Mhote (Waterlift).
4. Trials of Japanese Grain Screen and Paddy Seed Drill.
5. Investigating the possibility of using a better hand tool for harvesting.
6. Experiments on mechanical harvesting of paddy.
7. Experiments on the use of buck-scraper and level terracer for levelling the fields.
8. Operation of stationary machines by using bullock gear.
9. Trial and testing of imported agricultural machines and implements.
10. Modification and improvement of bullock-*cum*-power reaper.
11. Investigations of methods and implements for making 'Bunds' for soil conservation work.

PART. III—APPENDICES

Appendix I

Gazetted staff of the I.A.R.I. during 1952-53

1. Director	Dr. B. P. Pal, M.Sc., Ph.D. (Cantab.), F.N.I., F.L.S., F.B.S.
2. Registrar	Shri J. M. Banerjee, M.A. (Upto 9-12-1952.)
3. Personal Assistant to the Director.	Shri K. C. Gupta. (Reverted to the post of Superintendent on 10-12-1952.) Shri J. M. Banerjee, M.A. (Reverted on 10-12-1952.)
4. Librarian (Non-gazetted, Class II)	Shri N. N. Chatterjee.

DIVISION OF AGRONOMY

1. Head of the Division and Principal, Central College of Agriculture.	Dr. T. J. Mirchandani, M.Sc., Ph.D., A. I. I. Sc.
2. Agronomist	Dr. P. C. Raheja, M.Sc., Ph.D. (On deputation to U. S. A. for six months from 29-4-1953.)
3. Agronomist	Dr. N. P. Datta, M.Sc., D. Sc. (On deputation to U. S. A. for six months from 29-4-1953.)
4. Agronomist	Shri J. J. Chandani, M.Sc. (Ag.). (Officiating from 29-4-1953.)
5. Agronomist	Shri A. R. Khan, M.Sc. (Officiating from 29-4-1953.)
6. Agronomist	Shri S. Sen, M.Sc.
7. Assistant Agronomist	Shri A. R. Khan, M.Sc. (Till 28-4-1953.)
8. Assistant Agronomist	Shri J. J. Chandani, M.Sc. (Ag.). (Till 28-4-1953.)
9. Assistant Agronomist	F/Lt. R. D. Verma, B.Sc., B.Sc. (Edin.) (On deputation to U. S. A. with effect from 5-2-1953.)
10. Assistant Agrostologist	Shri P. M. Dabadghao, M.Sc.
11. Assistant Statistician	Shri P. N. Saxena, M.A.

DIVISION OF BOTANY

1. Head of the Division	Dr. N. Parthasarathy, B.Sc., B.A. (Ag.), Ph. D. (Till 8-9-1952.) Dr. R. D. Asana, M.Sc., Ph. D., D. I. C. (From 9-9-1952.)
2. Plant Physiologist	Dr. R. D. Asana, M.Sc., Ph.D., D.I.C. (Till 8-9-1952.) Shri T. J. Malkani, M.Sc. (Officiating from 9-9-1952.)
3. Geneticist	Shri R. B. Deshpande, M.Ag., Assoc. I.A.R.I.
4. Cytogeneticist	Dr. P. N. Bhaduri, Ph.D.
5. Systematic Botanist	Dr. D. Chatterjee, M.Sc., Ph.D. (London).
6. Wheat Breeder (Co-ordinated Wheat Rust Control Scheme).	Dr. G. S. Murty, M.Sc., Ph.D., Assoc. I.A.R.I.
7. Assistant Plant Physiologist	Shri T. J. Malkani, M.Sc. (Till 8-9-1952.)
8. Assistant Cytogeneticist	Dr. A. B. Joshi, M.Sc., Ph. D., Assoc. I.A.R.I.
9. Assistant Botanist	Shri H. B. Singh, M.Sc., Assoc. I.A.R.I.
10. Assistant Economic Botanist	(Lying vacant at present.)
11. Assistant Wheat Breeder (Co-ordinated Wheat Rust Control Scheme).	Shri S. Sen, M.Sc.

DIVISION OF AGRICL. CHEMISTRY & SOIL SCIENCE

1. Head of the Division	Dr. S. P. Raychaudhuri, M.Sc., Ph.D. (Lond.), D.Sc. (Cal. & Lond.), F.R.I.C

2. Soil Microbiologist . . .	Dr. S. V. Desai, B.Sc., Ph.D., D.Sc., D.I.C. (On deputation to Rajasthan.) Dr. N. D. Vyas, M.Sc., Ph.D. (Officiating.)
3. Soil Survey Officer . . .	Dr. R. V. Tamhane, B.Ag., Ph.D. (Lond.)
4. Biochemist	Dr. N. B. Das, Ph.D.
5. Organic Chemist	Dr. K. C. Gulati, B.Sc. (Hons. Tech.), M.Sc. (Hons.), Ph. D.
6. Experimental Physicist . .	Dr. C. Dakshinamurti, M.Sc., Ph.D. (Lond.), D.Sc. (Banaras.)
7. Fertilizer Technologist (T.C.A. Scheme).	Shri M. A. Idnani, B.Sc. (Hons.), Assoc. I.A.R.I. (From 24-2-1953.)
8. Assistant Soil Microbiologist .	Dr. A. Sen, M.Sc., Ph.D., Assoc. I.A.R.I. (From 10-3-1953.)
9. Assistant Soil Survey Officer .	Dr. K. V. S. Satyanarayana, B. Sc. (Ag.), Ph.D., Assoc. I.A.R.I.
10. Assistant Soil Survey Officer .	Shri L. M. Mathur (Offg.), M.A., B.T., A. S. T.
11. Assistant Organic Chemist .	Dr. A. C. Bose, B.Sc. (Hons.), Ph.D. (Lond.), A.I.C. (Lond.)
12. Assistant Organic Chemist .	Dr. A. R. S. Kartha, M.Sc., Ph.D.
13. Assistant Physical Chemist .	Dr. B. B. Roy, M.Sc., Ph.D. (Durham), A.R.I.C. (Lond.) (Relieved on 5-11-1952.)
14. Assistant Physical Chemist .	Shri B. Rama Moorty, M.Sc., A. R. I. C. (Lond.), Assoc. I.A.R.I. (Offg. from 7-11-1952.)
15. Assistant Soil Chemist . . .	Dr. C. N. Acharya.
16. Assistant Agricultural Chemist .	Shri M. A. Idnani, B.Sc. (Hons), Assoc. I.A.R.I. (Till 23-2-1953.)
17. Assistant Soil Physicist . .	Dr. B. T. Mulwani (Offg.), B. Ag., M.Sc., Ph.D. (Lond.), D.I.C.
18. Assistant Soil Chemist (T. C. A. Scheme).	Dr. B. V. Subbia, M.Sc., Ph.D. (From 23-5-53.)

DIVISION OF ENTOMOLOGY

1. Head of the Division . .	Dr. E. S. Narayanan, M.A., Ph.D. (Lond.), D.I.C., F.R.E.S.
2. Systematic Entomologist .	Dr. S. Mukherjee, M.Sc., D.Sc.
3. Insect Ecologist . . .	Dr. S. Pradhan, M.Sc., Ph.D. (Lond.), D.Sc., F.R.E.S., F.E.S.I.
4. Assistant Systematic Entomologist.	Shri B. B. Bose, B.Sc. (On leave preparatory to retirement with effect from 17-4-1953.)
5. Assistant Systematic Entomologist.	Shri C. K. Samuel, B.Sc., Assoc. I.A.R.I.
6. Assistant Insect Epidemeologist.	Shri T. V. Venkatraman. (Returned from deputation on 12-6-1953.)
7. Assistant Insect Physiologist .	Dr. Rattan Lal, M.Sc., Ph.D.

DIVISION OF MYCOLOGY

1. Head of the Division .	Dr. R. S. Vasudeva, D.Sc. (Lond.), Ph.D. (Lond.), D.I.C., F.N.I. (On deputation to U. S. A. for 3 months from 18-6-1953.)
2. Systematic Mycologist . .	Dr. B. L. Chona, B.Sc., Ph.D. (Lond.), D.I.C. (Lond.) (On deputation to U. S. A. from 15-2-1953 to 10-7-1953.)
3. Mycologist (Co-ordinated Wheat Rust Control Scheme).	Dr. R. Prasada, M.Sc., D.Sc.
4. Assistant Plant Pathologist .	Dr. M. L. Gattani, M.Sc., Ph.D. (Minn.) (Returned from deputation to the Rajasthan Govt. on 10-11-1952.)
5. Assistant Plant Pathologist .	Dr. R. S. Mathur, M.Sc., Ph. D.
6. Assistant Virologist . .	Dr. S. P. Raychaudhuri, M.Sc., Ph.D. (Cal.), F.L.S., Assoc. I.A.R.I. (Returned from study leave on 27-8-1953.)
7. Assistant Plant Bacteriologist .	Dr. M. K. Hingorani, B.Sc. (Agr.), Ph.D. (Minn.), Assoc. I.A.R.I.

DIVISION OF AGRICULTURAL ENGINEERING

1.	Head of the Division . .	Shri R. V. Ramiah, B.E. (Mech.), M.Sc. (A.E.), M.A.S.A.E.
2.	Mechanical Engineer (Extension)	Shri D. N. Kherdekar. (From 9-10-1952 to 30-6-1953.)
3.	Assistant Engineer . . .	Shri A. K. Kaul, I.E.E. (Expired on 12-9-1953.)
4.	Assistant Engineer . . .	Shri J. S. Manku, B.Sc. (Elect. and Mech. Engg.)

AGRICUTLURAL RESEARCH SUB-STATION, KARNAL

1.	Assistant Agronomist . .	Shri B. D. Ganguly, B.Sc. (Ag.)

BOTANICAL SUB-STATION, PUSA

1.	Superintendent . . .	Shri M. D. Nandkeolyar, M. Sc.
2.	Assistant Wheat Breeder (Co-ordinated Wheat Rust Control Scheme).	Shri S. Kedhar Nath, M.Sc.

CO-ORDINATED WHEAT TRUST CONTROL SCHEME, SIMLA

1.	Assistant Wheat Breeder . .	Dr. S. Kohli, M.Sc., Ph.D.
2.	Assistant Mycologist . .	Shri V. C. Lele, M.Sc.

CENTRAL COLLEGE OF AGRICULTURE

1.	Principal	Dr. T. J. Mirchandani.
2.	Lecturer in Agronomy . . .	Dr. Jaswant Singh.
3.	,, ,, Chemistry . . .	Dr. W. B. V. Sundara Rao.
4.	,, ,, Entomology .	Dr. Sardar Singh.
5.	,, ,, Physics . .	Dr. Y. V. Kathavate.
6.	,, ,, Agricl. Engg. .	Shri J. R. Badola.
7.	,, ,, Voty. Science .	Dr. Gian Singh.
8.	,, ,, Horticulture .	Dr. G. S. Randhawa.
9.	,, ,, Mycology . .	Dr. Suryanarayana, Ph.D.
10.	,, ,, English . .	Shri S. L. Vachhar, M.A.

Appendix II

Training of students and Research Workers during 1952-53

(*a*) List of students awarded the Postgraduate Diploma :—

Division of Agronomy

	Name of students	Subject of thesis
1.	Sri K. S. Cheema	Mixed cropping 'Rabi'-Barani (Wheat & Gram).
2.	„ N. T. Sarnaik	Seed rate-*cum*-varietal-*cum*-manurial experiment on wheat.
3.	„ Gurcharan Singh	Cultural-*cum*-manurial-*cum*-varietal trial on sugarcane.
4.	„ G. L. Luthra	Placement of fertilisers on maize.
5.	„ M. G. Kelkar	Varietal-*cum*-manurial trial on sugarcane.
6.	„ K. P. Gupta	Varietal trial with tobacco.
7.	„ R. P. Singh	Placement experiment with peas varieties.
8.	„ S. S. Singh	Effect of low doses of phosphates on berseem and in building up of soil fertility.
9.	„ V. R. Baporikar	Varietal-*cum*-manurial-*cum*-cultural experiment on linseed.
10.	„ S. D. Choubey	Varietal-*cum*-manurial experiment with barley.
11.	„ A. Misra	Soil fertility building value of 'guar'.
12.	„ B. B. Bose	Influence of depth of furrow in irrigation of potato.
13.	„ M. R. Bajpai	Response of berseem to fertilizers and comparison of after effects with direct manuring of cereals.
14.	„ O. P. Awasthi	Cultural-*cum*-manurial experiment on maize II (Hoeing, manures and placement).
15.	„ R. D. Singh	Cultivation-*cum*-manurial experiment in a rotation of maize-berseem, fallow-wheat (Heavy soil).
16.	„ S. S. Chauhan	Cultural experiment on jute.
17.	„ R. Satpathy	Varietal-*cum*-manurial experiment on N. P., Pb., and U. P. wheat.
18.	„ D. P. S. Teotia	Comparison of response to sulphate of ammonia oil cake and F.Y.M. at different levels of nitrogen on wheat.
19.	„ S. C. Sharma	Manurial-*cum*-cultural experiment on Maize I.
20.	„ A. K. Das Gupta	Potato cultural experiment started at Karnal.
21.	„ B. Choudhury	Varietal-*cum*-manurial trial with potato.
22.	„ P. S. Mahalle	Economics of green manuring.
23.	„ N. T. Badhe	Lay farming—New.
24.	„ N. B. Basnyat	Phosphate manuring of Hubam Clover and its effect on soil fertility.

Division of Botany

25.	„ K. P. Sharma	Further studies on autotetraploids of linseed (*Linum usitatissimum* L.) with reference to their behaviour as compared with their respective diploids.
26.	„ Y. R. Ahuja	Studies in the fertility of autotetraploids of toria.
27.	„ Ram Gopal	Studies on the influence of synthetic growth regulators on growth and development of wheat.
28.	„ S. M. Vaidya	Further studies on lodging in wheat. Determination of the most suitable index of lodging under different environmental conditions.

Division of Botany—contd.

	Name of students	Subject of thesis
29.	Sri K. A. R. Khan	Inheritance studies in F'' of some varietal crosses in *Linum usitatissimum* L.
30.	„ D. K. Ved Pathak	Correlation of characters (morphological and agronomical) in the different types of pigeon pea.
31.	„ G. H. Maduram	Studies on some cultivated varieties of a few genera of *Leguminoseae* with special reference to their range of variation.
32.	„ S. C. Pokhriyal	Cytogenetical studies of the hybrids of *Triticum vavilovi* with some of the other hexaploid wheats and of the back-crosses of the off-types derived from some of them.
33.	„ H. K. Mohanty	Cytogenetical studies of some interspecific hybrids of Triticum.
34.	„ C. L. Dhawan	Inheritance of Rust Resistance in wheat (A critical Review).
35.	„ M. G. Joshi	Inheritance studies in some intervarietal crosses of wheat.

Division of Chemistry

36.	„ Nanak Saran Sinha	Study of saline soils of the Delhi State.
37.	„ W. G. Walunjkar	Fertilizing value of some indigenous source of manures.
38.	„ P. M. Tamboli	Effect of tractor cultivation on black soils of Malva.
39.	„ Janardhan Jha	Effect of growing legumes on the chemical and microbiological properties of the soil.
40.	„ T. R. Shrinivasan	Studies on the production of nicotine sulphate from tobacco waste.
41.	„ Y. P. Bali	Soil and land utilisation survey of *Dabar* area in Delhi State.
42.	„ B. G. Prasad	Nicotinic acid and riboflavin contents of different varieties of Indian wheat and the effect of manurial treatments on their contents.
43.	„ K. K. Jha	Relationship between the plant phosphate and soil microorganisms.
44.	„ A. B. Lal	Studies on the clay fractions of red and lateritic soils of Bihar.
45.	„ S. Perumal	Nature of Laterite soils (Hyderabad State, India).

Division of Entomology

46.	„ S. Seetharaman	Studies on host-selection by the parasite *Trichogramma evanescens minutum R.* (Hymenoptera Chalcididae).
47.	„ V. G. Prasad	Systematic study of *Pyrilla* spp. infesting sugarcane in India.
48.	„ Ejazul Huq	Longevity and fecundity of an aphid predator, *Sphaerophoria scutellaris* F.
49.	„ S. K. Prasad	Studies on the distribution and sampling of insect pests.
50.	„ Mohd. Imran	Longevity and fecundity of *Trichogramma evanescens minutum* R. at different temperatures and relative humidities.
51.	„ R. A. Agarwal	Persistence of modern insecticides in sugarcane and cotton crops.
52.	„ Abdulla Khan	Susceptibility of different stages of Locust (*Schistocercagregaria* F.) to insecticides.
53.	„ G. I. D'Souza	Water relations in some Indian insect pests.
54.	„ J. M. Satpathy	Comparative toxicity of different modern insecticides to some Indian insect pests.

Division of Mycology and Plant Pathology

Name of students	Subject of thesis
55. Sri P. B. Chakravarti . .	Further studies on antibiotic action of *B. subtilis* in relation to *Fusarium udum* and certain other parasitic fungi.
56. „ A. N. Nagraj . . .	Mosaic and Leaf Curl diseases of Petunia.
57. „ D. D. Srivastava . .	Fusarium wilt of Chillies.
58. „ M. A. Vishwanathan . .	Comparative morphological and pathological studies of *Peronospora* spp. of Delhi.
59. „ A. J. Hathi . . .	Comparative morphological and pathological studies of *Colletotrichum* spp. parasitic on Graminaceous hosts with particular reference to Red Rot of Sugarcane.
60. „ Satpal Singh . . .	Inheritance of pathogenicity in *Melampora lini*.
61. „ P. P. Mehta . . .	Brown rot of potatoes.
62. „ K. R. Sreekantiah . .	Fungus flora of stored seed grains.

(*b*) Students admitted during the year :—

Agronomy

1. Vasudeo Balwant Rahudkar
2. Pran Nath
3. Kironmoy Dutt
4. Pyara Singh
5. Dhirendra Kumar Sharma
6. Vasant Dariha Mane
7. Tarun Kumar Ghosh
8. Amrit Martandrao Deshpande
9. Jagannath Prasad Patel
10. Mahesh Behari Lal
11. Shibani Pada Roy
12. Vithal Tanbajee Rahate

Botany

1. S. Bhaskaran
2. Patu Narsimha Rao
3. Bibhuti Ranjan Majumdar
4. Jiban Kumar Chandra
5. Vivek Prakash
6. Sujan Kumar Joshi
7. Badrinath Vishwanath Das
8. Rajindra Kumar Agarwal
9. Purshotam Ramchandra Chopde
10. Balwant Ganpatrao Ghawghawe

Chemistry

1. Sharadchandra Jagannath Lote
2. Moti Lal Khybri
3. Nilkanth Dulishchandra Bhure
4. Madhabendra Mohan Guha
5. Mohammed Nizamuddin Malik
6. Maheshwar Prasad Sinha
7. Brijendra Nath Srivastva
8. Baljit Singh
9. Kunverji Laxman Jadav
10. Vishnu Kumar Misra
11. Uma Prasad Misra

Entomology

1. Sant Kumar Golhani
2. Bhupender Kumar Rai
3. Ashok Kumar Sharma
4. Sawraj Kumar Bhatia
5. Ram Narain Prasad
6. Sayed Zulfaquar Haider Naqvi
7. S. Nagarajan
8. Krishna Rajaram Thakare
9. Govind Gangrade
10. Hari Singh Chachoria
11. Kandikuppa Krishnamurthi

Mycology and Plant Pathology

1. Rajindra Kumar Grover
2. Telikpalli Venkata Sabbaiah
3. Harish Chandra Prasad
4. Virendra Kumar Pathak
5. Om Prakash Fatehchand Sharma
6. Durga Charan Beohar

Plant Protection Course

1. Jagdish Chander
2. Atma Ram Chauhan

Short Course in Soil Survey

1. S. K. Dasgupta
2. N. D. Banerjee
3. N. T. Leela Ram

. . 6 months course.

M.Sc. Punjab students

1. B. Kapoor
2. Inder Singh
3. Harbans Singh
4. Shiv Kumar
5. Om Prakash Mehra
6. Rattan Singh
7. Peramod Kumar

(*c*) Students admitted for short course training during the year :—

Chemistry

1. Het Singh Andotra
2. Miss Narayan

(*d*) Honorary Research Workers :—

Agronomy

1. H. Gurubasavaraj

Botany

1. Ram Gopal
2. N. L. Dhawan

Chemistry

1. D. J. Gooptu
2. A. K. Das
3. C. L. Gupta
4. R. Narayana
5. O. P. Chawala
6. I. D. Dharmi

Entomology

1. M. P. Joseph
2. Vinai Singh

Mycology and Plant Pathology

1. Y. K. S. Murthy
2. Rajinder Singh Ahuja

Appendix III

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